POWER

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Are You Looking for an Engineer?

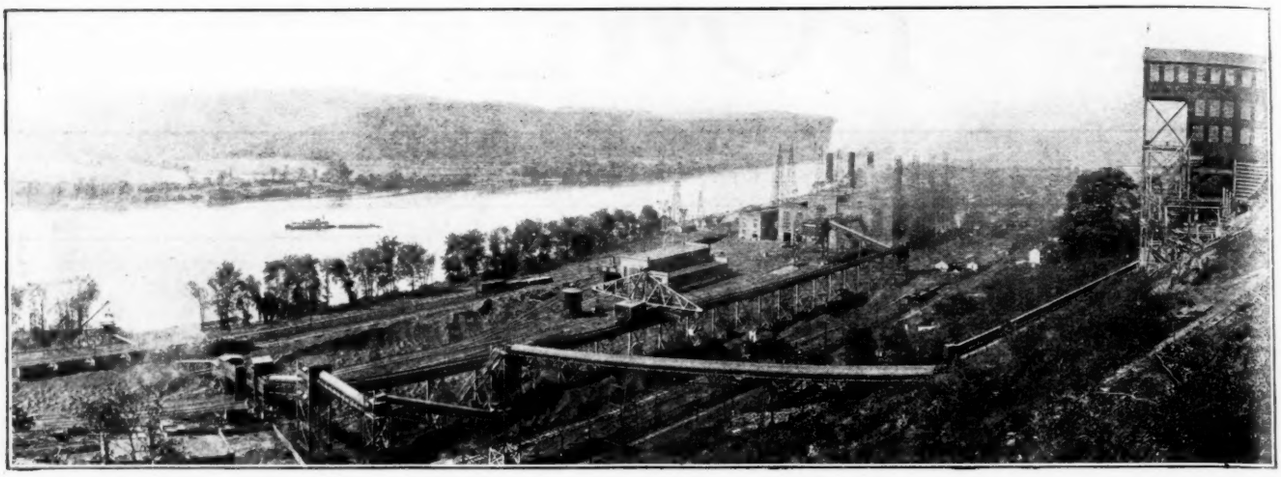
SOME weeks ago I wrote that *Power* would like to be of service in bringing men and jobs together. Many a good man capable of bigger things passes his life in ministering to the necessities of a small plant because he gets stranded there and has no contacts which get knowledge of him and his capabilities over to those who are looking for men of his type.

On the other hand, one of the difficulties of the responsible chief engineer or power-plant superintendent is that of keeping up his organization, of finding men upon whom he can lean, to whom he can turn over certain divisions of his work with the confidence that it will be done right; men who will work with him rather than for him, with their eyes upon the plant record rather than upon the clock and their ambitions focused upon greater knowledge and opportunity rather than upon the paymaster; men who are competent of co-operation and team work, who will bring harmony and good-natured emulation rather than dissension and personal animosities into the organization.

As was natural, the offer has brought out many letters from men who would like to improve their condition, but few from those who have opportunities to offer. The services of *Power* are at the command of those having present or prospective vacancies in their staffs in bringing them in contact with those seekers for advancement, the letters of many of whom have indications of real merit.

It goes without saying that communications of the sort invited will be treated as confidential on both sides, and that *Power's* only purpose is to render a service that will be a source of mutual satisfaction.

F. R. Low



Coal Sorted, Stored and Transported by Belt-Conveyor System

THERE are five possible means of supplying coal to the 180,000-kw. plant of the Beech Bottom Power Company, at Power, W. Va. The mine whose tipple appears at the right-hand side of the headpiece is sufficient for fifty years of operation at the maximum capacity and present efficiency of the plant. Besides this, coal may be supplied by water, steam railroad, the electrical railroad and by trucks. The belt-conveyor system may receive fuel from any of these sources. Coal is crushed, weighed, screened and stored. The Ohio Power Co. and the West Penn Power Co. jointly own this plant, situated twelve miles north of Wheeling, W. Va., on the Ohio River.

The plant at present contains six 30,000-kw. main units. Its ultimate capacity is eight units. Twenty-five hundred tons of coal is now required per day. The conveyor system may deliver five hundred tons per hour, at normal load, so that five hours' operation out of the 24 is practically sufficient. The system, however, may be subject to a considerable overload if necessary. It is estimated that the coal used at this station during the year 1922 would have required a freight train 95 miles long. The various operations performed by this belt-conveyor system would require, otherwise, 35 steam locomotives and 1,000 freight cars, together with their crews. There is approximately one-half mile of conveying belt outside of the power house. When the mine becomes exhausted, however, only 500 ft., or about 20 per cent of this conveyor, will become obsolete, the remainder being necessary for handling coal from the other sources.

It can be seen from the headpiece that the conveyor runs from the mine tipple at the right to the landing at the side of the river. About midway between these two points is the connection to that part of the conveyor traveling over the storage area. This section is 855 ft. long, over which travels the distributing crane. The lower end is connected to the power house, which it enters by means of two belts, one for each coal bunker. Except for the duplicate belts entering the coal bunkers, single-belt systems are used throughout. The conveyor is covered except over the storage area.

A fifty-foot depth of coal storage is made possible by the conveyor system, which may screen the incoming coal, sending the fine to the power-house bunkers and the coarser lumps to the storage area. The distributing crane performs a number of functions in selecting and handling fuel. An atomized water spray arrests coal dust.

The map in Fig. 7 indicates to better advantage the general layout. The Pennsylvania railroad tracks are located next to the river. Inside of this may be the future electric railroad spur as well as the highway for trucks. The main electric railroad, as at present, appears on the map. That part of the conveyor extending to the water, therefore, will receive coal from either of the four sources named. Loading devices for the proposed electric railroad and for trucks have not been installed; future plans are not yet settled. The steam road belonging to the plant connects to the steam and also to the electric road. Tower *D* contains a loading device for these cars.

The main conveying belts are 48 in. wide, with smaller belts 36 and 30 in. in some cases. Those entering the coal bunkers are each 30 in. All belts are driven at one end with a single drive pulley in the usual manner, except that in the main storage. This is tandem driven at one end by means of two driving pulleys, with the addition of an idler to secure proper contact area. Larger belts operate at 300 ft. per min. and smaller up to 500.

The conveyor belts are electrically driven by 2,300-volt alternating-current motors. The distributing crane, however, utilizes 550-volt direct current for its equipment of eight motors.

The system is operated from the main control tower placed outside of the power house, shown in Figs. 1 and 7. In starting the system, it is only necessary for the operator to press one button. The two belts that enter the power house first begin to operate. Then the section of belt that connects to these starts, and after this is in operation, the belts that are next in

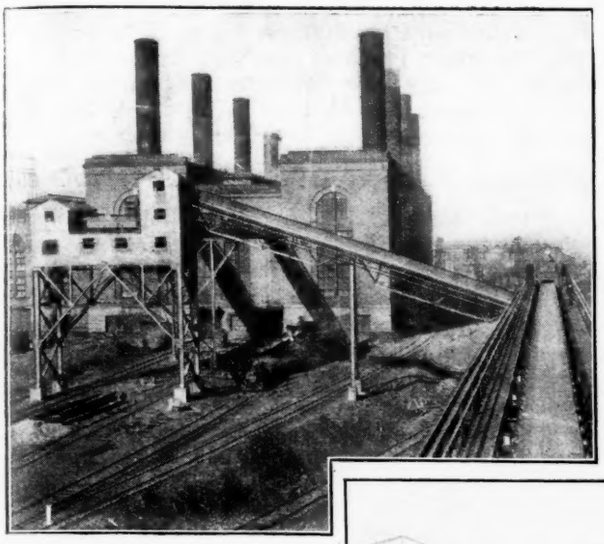


Fig. 1—The entire conveyor system is operated from the main control tower at the left. Pressing one button starts or stops all belt conveyors. On starting up, the belts entering the power house are first placed in operation. After that, each part of conveyor is started in succession. This prevents spilling of coal. Shutting down is accomplished in the opposite consecutive order.

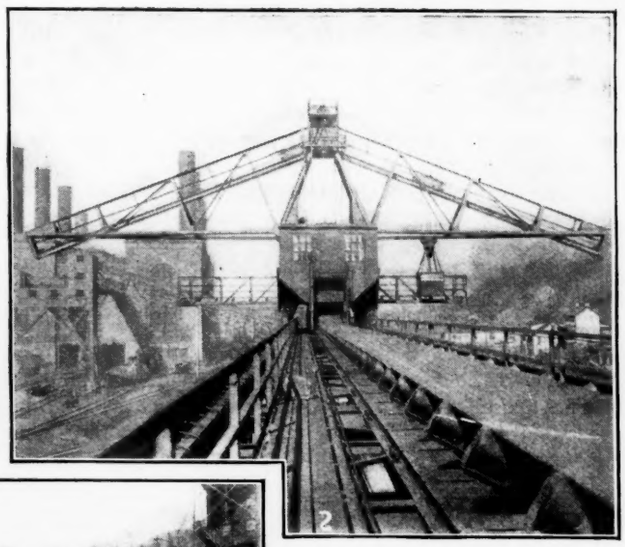


Fig. 2—The 48-inch conveyor belt is believed to contain the longest single piece of this width in use at the present time.

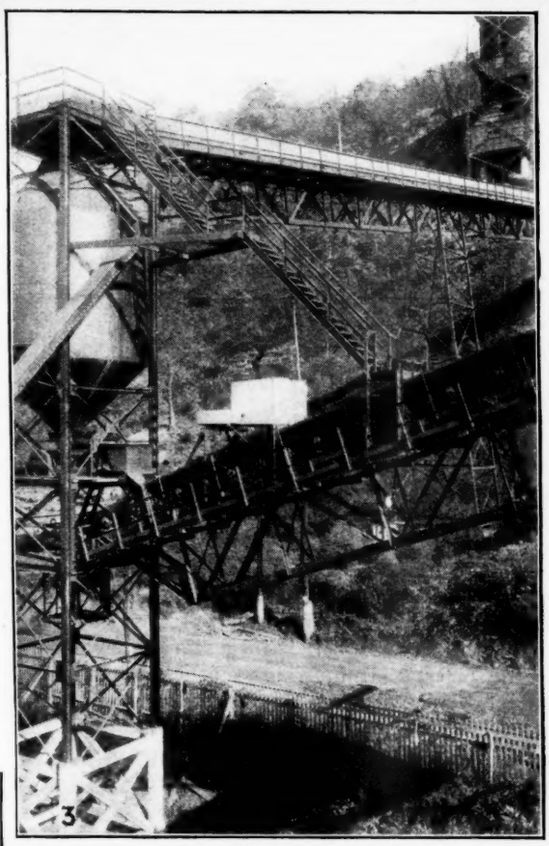
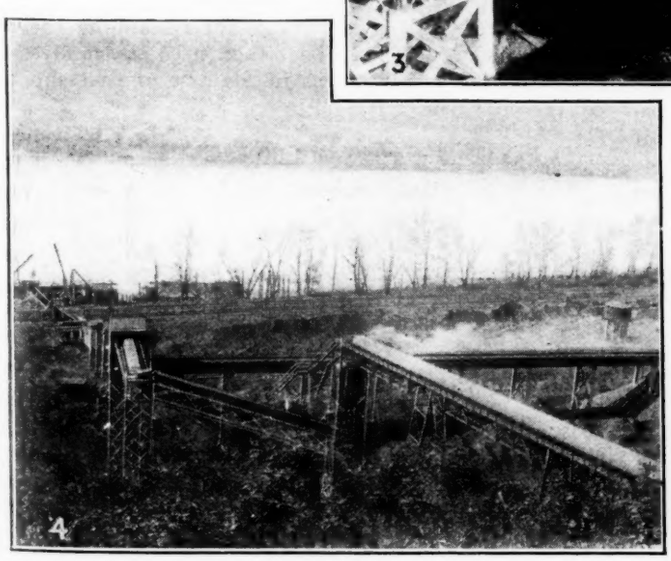


Fig. 3—The tank of 850 tons capacity absorbs the uneven flow of coal from the tipple. It feeds the removal belt at a more uniform rate. The weightometer, which is the box-like structure at the right of the tower, measures fuel from this source.

Fig. 4—A derrick and grab bucket unload coal from scows to the unloading bins which feed the conveying belt. Between the dock and the storage belt is placed a weightometer and a coal-crushing plant. A car-unloading device transports fuel from the plant railroad to the conveyor.



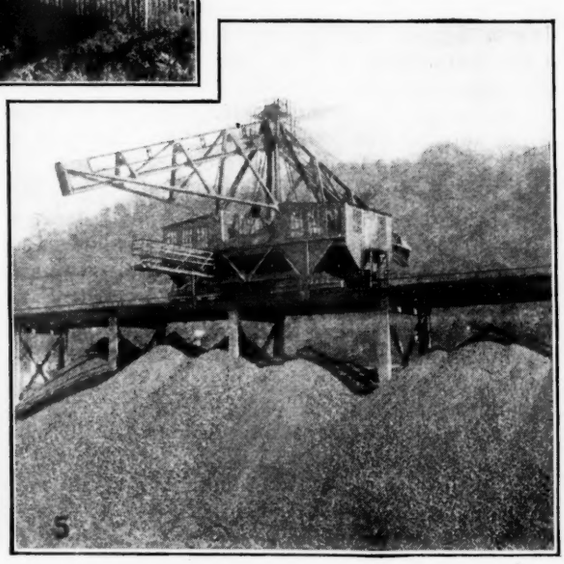


Fig. 5—The novel truss construction of the distributing crane is apparent. Gravity assists the outward travel of the grab buckets.

order. By means of the consecutive starting of the various conveyor belts, there is no piling up and spilling of coal on the belt ahead. When the system is shut down, it is customary to stop in the opposite succession, so that the belt farthest from the power house shuts down first, allowing each belt to clear itself before stopping. If coal were being furnished from the mine, the belt at the tipple would be the first to be stopped. The other belts would then be successively cut off as each one came to rest.

Hand-operated control switches are situated at intervals over the entire system. The tripping of any switch will stop that part of the conveyor between it and the source of supply. Belts between that section and the power house, however, will not be shut down. These switches are useful in general operating such as timing belt travel to correspond with coal-car delivery, etc. They are also useful for sudden stoppage, such as in the unloading pulley, atomized water is played on the mass of dust which has become separated to some extent from the larger grade of coal. A comparatively small amount of water may thus effectively attach the dust particles together, preventing objectionable blowing of the dust in transit.

Securing Adequate Storage on Restricted Area

Available storage area is greatly restricted between hills and the river bank. One of the problems was to store a sufficient supply of fuel near the plant. By means of storing only the coarser grade of coal and conveying the fine particles to the bunkers of the power house, to be burned, it is possible to use a 50-ft. depth of coal in the storage. Surface combustion in the larger lumps is so slow that undesirable heating does not occur at this depth, whereas with the finer particles of coal it would be dangerous unless special care were taken

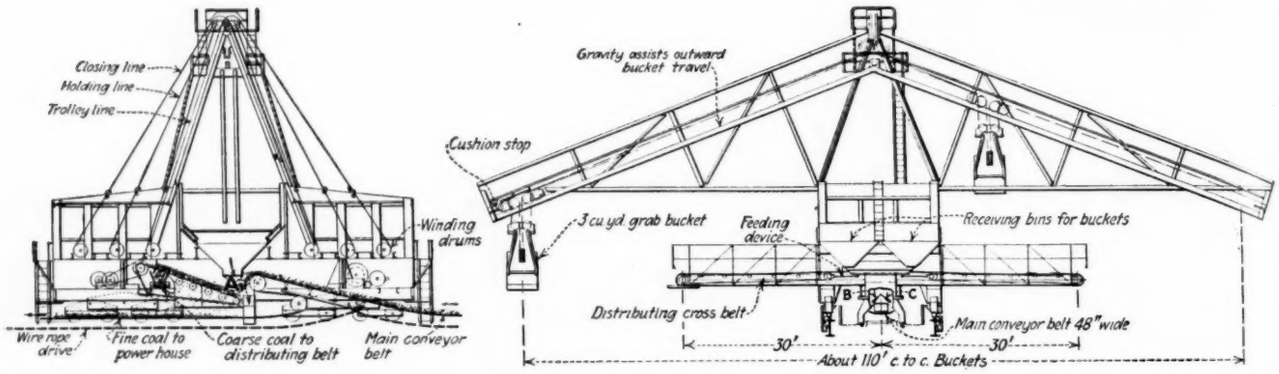


FIG. 6—DISTRIBUTING CRANE DESIGNED TO OPERATE IN A NUMBER OF WAYS, WITH NOVEL TRUSS CONSTRUCTION. TWO MID-SECTIONS OF CRANE ARE SHOWN.

the case of foreign objects getting mixed with the coal and requiring removal, or adjustments.

The main control tower also contains instruments showing the amount of coal passed over the belts as indicated by weightometers placed in different parts of the system. A weightometer is shown in Fig. 3, where the coal from the tipple is conveyed to the main belt. Weightometers are also placed on the belts leading to the coal bunkers, recording the amount of coal going into each bunker, and also on the section of the conveyor between the river and the main belt. Three coal crushers are installed just below the tipple, and another one in tower marked *C* on the map, which serves the river unloading system. Scaffolding in the headpiece hides the crushers at the tipple. These crush the coal to sizes suitable for stoker operation. One and a-half inch cubes are the largest desired.

The distributing crane and the storage yard are shown in Figs. 2 and 5. In Fig. 3 is a tank which collects the coal received from the tipple and regulates the flow into a small belt leading to the tower at *B* in Fig. 7. The tank is indicated at *A* in this figure. This has a capacity of 850 tons, and is required because the coal supply from the mine is occasionally intermittent. A more uniform supply for the belts is obtained by means of a suitable feeding device.

A novel method of arresting coal dust is installed in connection with the tank in Fig. 3. An atomized water spray is utilized in an effective manner to bind the dust particles together. The fine particles tend to settle close to the belt surface of the conveyor, with coarser particles on top. As the run-of-mine coal leaves the belt at to pack them tightly. The coal storage has a capacity of 130,000 tons. This represents 52 days' supply at the present rate.

The distributing crane performs a number of functions. Coal received from the mine or any other source may be screened. The larger lumps may be distributed into storage by means of a reversible cross-belt. On the other hand, the entire run-of-mine coal may be allowed to proceed straight to the power house. Run-of-mine coal may all be stored, or partly stored and the remainder sent to the coal bunkers. This crane is also fitted with grab buckets for reclaiming the coal in storage, which may be either used as received or screened and separated, as in the case of that supplied by the conveyor.

Novel Crane Trusses and Gravity Runway

The distributing cross-belt can be clearly seen toward one end of the crane in Fig. 5. Other features of this crane include a slanted crane runway, in which gravity assists the outward swing of the buckets. The trusses are also of novel construction. They are solidly connected along the topmost member, while the two lower members come together at the extreme ends and yet are separated at the crane widely enough to permit the buckets to pass through. It will be noticed that this design gives greater rigidity than two trusses that are placed parallel and connected together by bracing of the usual kind. The lower trusses do not require to be wide apart at the extreme ends, since it is only necessary to have clearance for the hoisting cables at this point. In Fig. 5 one of the grab buckets is shown at

rest in the hopper at the middle of the crane. In Fig. 2 the other grab bucket is shown partly suspended from the truss. The entire elevated structure is given an ample allowance of strength to resist wind pressure. The crane is automatically locked when the power is off, so that it cannot be moved by wind. There is a safety device on the buckets which locks them in place in case the cables used for the rope drive, for moving them, break.

When the door *A*, Fig. 6, is turned to the right, incoming coal, whether from the belt or from storage, is led to the grizzly. The traveling conveyor moves the lump coal that does not fall through, to a point where it falls on the cross-belt. The location of the cross-belt is indicated in Fig. 6, which gives two mid-sections of the crane. This may then be distributed to any part of storage as desired. The finer particles are allowed to drop through on the main belt before traveling as far as the cross-belt. They are, therefore, sent to the power house bunkers. The cross-belt conveyor is reversible and may discharge the material into storage on either side, as desired.

When the movable gate *A*, Fig. 6, is thrown to the left, coal may be received from the main belt and deposited upon the two gates *B* and *C*, shown at the right. This coal will then be dropped into storage by the two chutes on each side of the center line, one on the right and one at the left in Fig. 6. However, if both of the doors *B* and *C* are thrown apart, the chutes will be closed and the coal will be allowed to drop on the main belt below. This belt travels toward the power house and will then take the run-of-mine coal directly to the bunkers. If one of these doors is closed, as before, say *B*, then part of the coal will be allowed to go to storage through the left-hand chute, while part of the coal will also be placed on the belt for the power house. If there is no coal received over the conveyor, the reclaiming buckets may dump into the hopper of the crane, so that fuel will then pass by the door *A* in the same manner as coal from the belt. Coal from both sources, of course, may be handled at the same time and in the same manner as that from either one.

The traveling buckets use four-wheel trolleys equipped with electric limit switches and brakes, as well as the automatic safety devices which operate in case a trolley cable breaks. This is similar to the automatic brake of an elevator and functions whenever the tension of this cable is released.

The crane is propelled along the runway by dual continuous rope drives located beneath the floor. The driving motor is equipped with a solenoid brake so arranged that when the crane is not operating along the runway, it is at all times locked against movement by the wind or other force. Eight motors altogether complete the equipment of the crane. These are, one drive motor, one motor for the traveling grizzly and lateral belt conveyor, two motors for hoisting each bucket which include one each for closing and raising, and two for the lateral movement of the buckets.

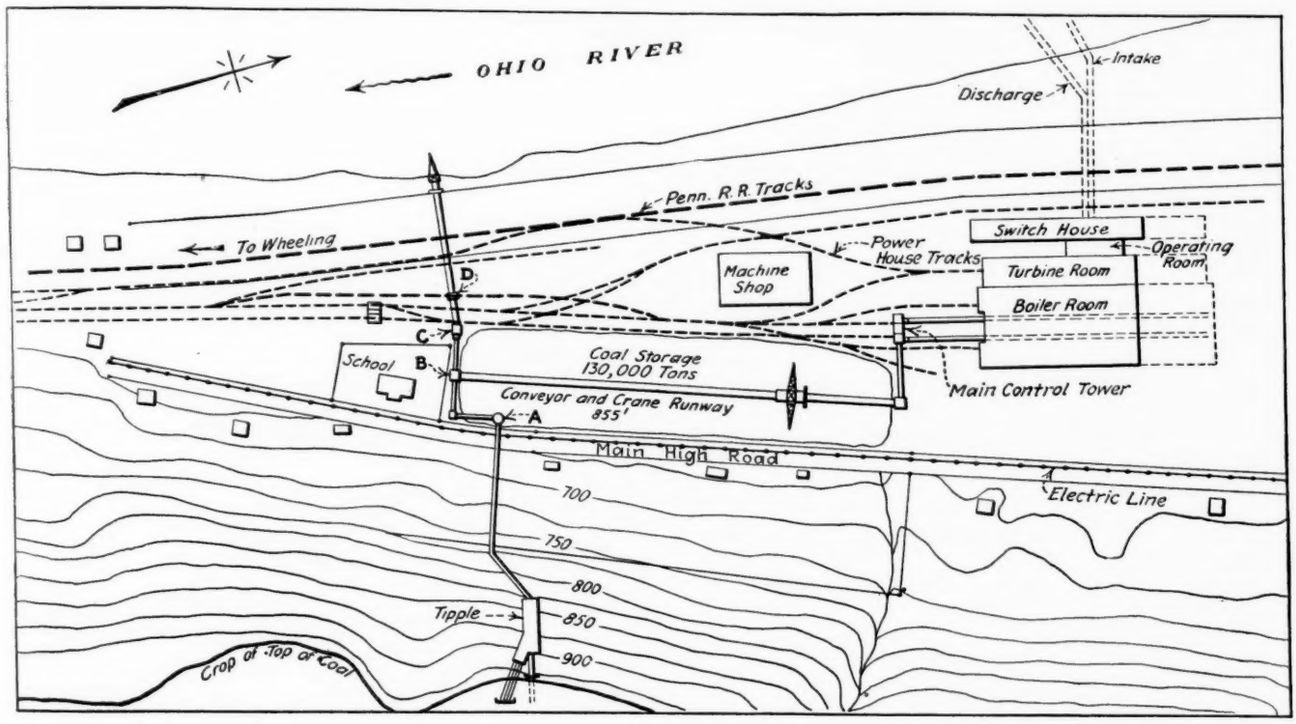


FIG. 7—STORAGE AREA RESTRICTED BY HILLS AND RIVER. SELECTING LARGER-SIZE COAL MAKES A FIFTY-FOOT DEPTH OF STORAGE POSSIBLE

Several Ways of Supplying the Bunkers

With regard to reliability, this system is, in the first place, considerably larger than necessary for continuous operation. Five hours' running out of 24 is now sufficient for the needs of the plant. Thus there is a large margin of time for maintenance in each day.

If coal were cut off from the mine by the failure of the conveyor between the tipple and tower *A*, there would be available coal from storage or from either of the four outside sources. If, however, trouble occurs so as to stop the conveyor between the towers *A* and *B*, Fig. 7, the tank at *A*, shown also in Fig. 3, would ab-

sorb some of the coal from the tipple, and when this was full, the overflow would spill directly into storage. There would be available other coal, as before mentioned.

In case of a failure from either of the five outside sources of coal, there is still the large capacity of storage available for the bunkers. The basement of the power house also contains storage for 36 hours' operation.

If the entire conveying system should be incapacitated, there are the original tracks, locomotive crane and coal cars which were used for supplying the power house before the belt conveyor was completed. Fuel may thus be supplied to the interior of the boiler room and elevated by means of bucket conveyors.

The entire coal-handling system was designed and detailed in the New York offices of the American Gas and Electric Company.

The Mercon Regulator

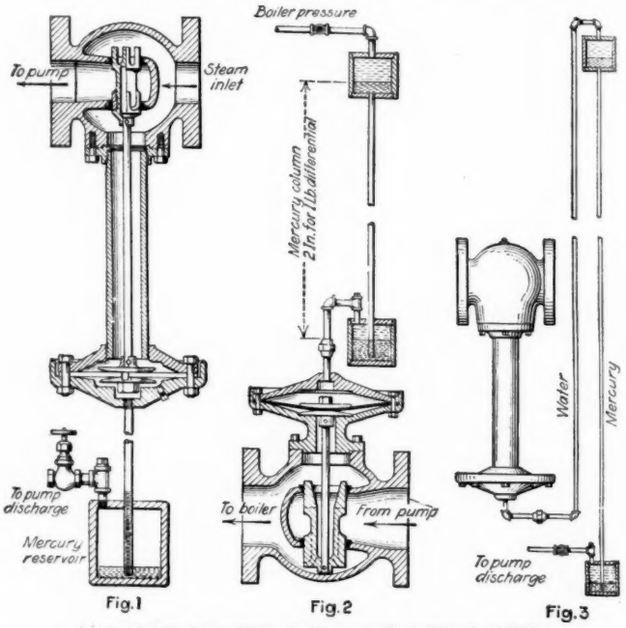
In feeding water into a boiler, the pump pressure must be greater than the boiler pressure in order that the pipe and valve friction may be overcome and the water raised from the pump to the water level in the boiler. The amount of this excess pump pressure determines the rate of flow, and if the differential is held constant, a constant rate of flow will be maintained. Under such conditions a feed-regulating valve at the boiler will function properly and control accurately the flow into the boiler, regardless of variations in steam pressure.

An excess-pressure regulator for both steam- and motor-driven boiler-feed pumps designed to maintain a constant differential has been brought out by D. H. Skeen & Co., 407 South Dearborn St., Chicago. The regulator is of the diaphragm type, employing a mercury column instead of the usual spring or weight to act with the steam pressure to balance the pump pressure. The idea originated with C. J. Smith, chief engineer of the Inland Steel Co. The violent load fluctuations in a steel mill and the consequent variation in steam pressure emphasized the need of such a device.[1]

Fig. 1 shows the present design of the regulator. It will be seen that a balanced valve regulates the steam supply and therefore the pump speed. The mechanism consists of a balanced valve of the hollow piston type, a rubber diaphragm and a mercury column. The diaphragm is below the valve and is protected from the temperature of the steam by the condensation filling the neck joining the valve body with the diaphragm. Below the diaphragm is the mercury column and at the bottom, the mercury well. A small pipe connection extends from the pump discharge or feed line to the mercury reservoir, so that when the regulator is in operation, the feed-pump pressure at the lower reservoir must support the column of mercury and exactly balance the steam pressure on the upper surface of the diaphragm. Any increase in steam pressure will tend to force down the diaphragm, open up the steam valve and speed up the pump. This will increase the pump pressure sufficiently to balance the higher steam pressure plus the differential due to the mercury column. As the height of the mercury column is always the same, the excess of pump pressure over steam pressure is constant.

In addition to simplicity, lack of springs, weights, stuffing boxes, etc., one of the outstanding advantages of the regulator, adding to its longevity and the life of the diaphragm, is the fact that the pressures on either side of the diaphragm are balanced; that is, the pressures from below and from above are exactly equal over the entire area of the diaphragm surface. This permits the use of a diaphragm large in diameter and relatively thin, so that it is sensitive in action and gives the valve disk a travel approximating 40 per cent of the pipe diameter. A mercury column 2 in. high for each pound of differential is required, and it takes 1 lb. of mercury to fill 6 ft. of this column. Consequently, a 50-lb. differential would require a column 8 ft. 4 in. high and 1.4 lb. of mercury with an additional supply for the space under the diaphragm and the mercury well at the bottom.

Where an unusually large differential is desired or where there is not sufficient room below the regulator for the required height of mercury column, the system shown in Fig. 2 is employed. Fig. 3 shows the regulator adapted for a motor-driven pump. The regulator is installed in the pump discharge line with the diaphragm above the valve. The inlet is now at the opposite end of the valve. Running at a practically constant speed, the pump delivers water to the regulator at a pressure higher than is ever required by the feed system. The pressure on the outlet side balances the diaphragm against the mercury column plus boiler pressure. An increase in boiler pressure will depress the diaphragm and permit more water to pass until the outlet pressure is again equal to boiler pressure plus the differential due to the mercury column. The reverse action takes place with a reduction in boiler pressure. For feeding hot water the neck between the valve body and the diaphragm is made longer. If the upper mercury reservoir is open to the atmosphere, the regulator becomes a reducing valve and maintains a constant pressure at the outlet.



MERCON EXCESS PRESSURE REGULATOR

Fig. 1—Standard installation. Fig. 2—For large differential or lack of room below. Fig. 3—For motor-driven pumps.

Other applications of the regulator are as a steam-pressure reducing valve to maintain a constant pressure and as a constant back-pressure or relief valve.

[1]See *Power*, May 23, 1922, p. 824.

Low Temperature Carbonization of Coal

By DAVID BROWNLIE

As a British consulting engineer Mr. Brownlie has long specialized in matters relating to fuel economy and particularly the carbonization of coal. In this article he reviews most of the processes that have been devised, both here and abroad and ventures the opinion that the erection of a limited number of large plants would go far toward solving the problem.

THE enormous possibilities of the low-temperature carbonization of coal have not yet been realized to the fullest extent, although the amount of experimental work that is going on throughout the world, particularly in the United States, Great Britain, and Germany, is remarkable, and over thirty different processes are at present under active consideration.

With the exception of purely anthracitic coals, which comprise less than ten per cent of the total, one ton of coal of say twenty-five-thirty per cent volatile will give, by low temperature carbonization—taking the average figures for half-a-dozen or so of the more important processes—something like 2½ to 3 gallons of motor spirit, 18-20 gallons of valuable low-temperature oils, and 20 lb. sulphate of ammonia, together with 70 per cent residual low temperature fuel containing 10 per cent volatile matter. It should be emphasized also that this residual low temperature product is a much more efficient fuel than raw coal, as it burns smokelessly with a higher emission of radiant heat even than coke.

Economic Effects of Coal Distillation

It is staggering to reflect what it would mean if the whole of the raw coal consumed as fuel in the world was first subjected to low-temperature carbonization and the valuable products extracted. For the purpose of this argument one can take the world's coal consumption as 1,250,000,000 tons per annum, and probably something like 250,000,000 tons of this is already carbonized by high temperature methods, either in gas works or coke ovens. The low temperature carbonization of over nine hundred million tons of coal per annum would mean the annihilation of black smoke, and an enormous development in the internal-combustion engine. It is true that low temperature carbonization is not yet a commercial success, but the problems of large scale production appear near solution, and great interest has been attracted by the fact that Henry Ford is considering the possibilities in this direction.

During the last twenty years, and more especially the last ten years, an enormous amount of research experimental work has been carried out in connection with low-temperature carbonization, and many of the thirty or so different processes have been continuously investigated for 5 or 10 years past, while at least three—the "Coalite" in Great Britain, "Smith's Carbocoal" in the United States, and the "Fellner-Ziegler" process in Germany—have been working on a large scale and carbonized many thousand tons of coal. It is stated for example that during the past twenty years, since the original work of Parker, which commenced seriously in 1903, over 100,000 tons of coal have been carbonized according to the various patents and retorts of the "Coalite" process alone.

What is really required today is the erection of a limited number of large plants, say to carbonize 500 tons of coal per 24 hours, so as to give a thorough try-out to half-a-dozen or so of the most promising processes.

Low-temperature carbonization is of such vital importance to the world in general that it should really be made a national question, and from an engineering and scientific point of view, it is really appalling that for the cost of one battleship, which will be obsolete in a few years or may be sunk by a submarine or seaplane, we could go a long way towards solving the whole question.

Review of Existing Processes

It will not be without interest, therefore, to give a very brief survey of the different processes in vogue at the present time.

The simplest and most obvious method is merely to carbonize coal in small retorts at 1,000 deg. F. instead of 2,000 deg. F. as in the household gas and coke-oven processes. In practice, however, this has proved a troublesome operation, and it is only recently that the difficulties have been surmounted. The two chief processes on these lines are those of the "Coalite" and the "Tozer" which are primarily intended for the production of high grade household fuel. The chief advantage of this type of process, in which the coal is carbonized under high pressure while in a plastic condition, is that it gives an extremely high grade household fuel, with pure rich gas; the disadvantages are the small capacity of the retorts, the intermittent nature of the process, and the reduced yield of ammonia.

As opposed to this method there are a large number of processes in which the carbonization is carried out continuously, the coal being roughly pulverized, and the residual low-temperature fuel is therefore in the same condition, and the operation is not carried out under pressure. The first section of this general method is the use of a long horizontal revolving cylinder, externally heated, through which the coal travels continuously as it is being carbonized, on the principle of the "Wisner" process in the United States, the "Fusion Retort" in Great Britain, and the "Fellner-Ziegler" process in Germany. In Great Britain there is also the "Nielsen" process on these lines, in which, however, the carbonization is carried out by internal heating, using a current of producer gas at about 1,200 deg. F. water gas, or other gaseous material passed through the retort in the opposite direction to the travel of the coal.

Stationary Horizontal Retort Processes

What may be termed the second section of this principle is the use of a stationary horizontal retort, in which the coal is conveyed continuously by means of an internal screw conveyor, such as the "Summers" process—and partly the "Smith's Carbocoal" process—in the United States, and the "R. W. Easton" process

in Great Britain. Finally, there are modifications of this stationary horizontal retort, in which the coal is caused to travel on a continuous conveyor, which may be either in the form of a series of trays one behind the other, or cast-iron plates, as represented by the "Pritchard" and "Traer" processes in the United States, and the "Richards Pringle" process in Great Britain.

The Caracristi Process

The "Caracristi" process (described in *Power*, May 29, 1923) uses cast-iron plates, but is remarkable in the sense that the heating medium is a bath of molten lead, on the same general lines as proposed in Great Britain by J. T. Morgan. It is interesting that nearly a century ago in London, Samuel Clegg, along with Murdoch, the chief pioneer in the household gas process, constructed a plant on almost identical lines, using a travelling conveyor of cast-iron plates, the coal in a roughly pulverized condition being fed on continuously, and the coke being discharged at the other end. These plates were, however, heated by direct fires, and of course the process was intended to be a high temperature one.

The chief advantages of the continuous travel method of carbonization, according to these various modifications, are the greatly increased output of the plant and the reduced cost of labor, while the heat conductivity is considerably improved, and the carbonization is also homogeneous, as the material is being continually turned and mixed. The disadvantages are that, as a rule, a long retort is required, and the low-temperature fuel is not suitable for household purposes unless previously briquetted. It is, however, ideal for burning in the pulverized condition or for total gasification.

Power Gas Corporation Process

Another valuable development in low-temperature carbonization is that represented chiefly by the new "Power Gas Corporation" process in Great Britain, although the "Bussey" process in the United States, and the "Messel" and "Ziegler" processes in Germany are on the same lines. This is really a combination of low-temperature carbonization and total gasification, and in the case of the "Power Gas" process, is a modification of the old "Mond" gas method. The new plant consists of a deep producer, in which the coal in the top portion is subjected to low-temperature carbonization and the valuable oils, to the extent of 20 gallons per ton, are separated. The carbonization is carried out by the sensible heat of the gas struggling upwards from the lower part of the retort, and as soon as the partially carbonized fuel reaches this section, it is then completely gasified by means of an ordinary steam blast, so that the process is really one of total gasification, using the sensible heat to carbonize the coal at a low temperature on its way to total gasification. By this method it is possible to obtain, as for example in the "Power Gas" process, a yield of about 120,000 cu.ft. of low grade gas of 180 B.t.u. per cubic foot, 90 to 100 lbs. of sulphate ammonia—roughly characteristic of the original "Mond" process—with the addition of 20 gallons per ton of valuable low temperature oils instead of, as previously, only about 6 gallons per ton of useless tar. Several large plants on this principle are now at work in Great Britain, and important results are expected.

Another method that has been employed is the carbonization of briquetted fuel, that is, briquetting first and carbonizing afterwards. This, for example, is the principle adopted by the "Smith's Carbocoal" process, and in Great Britain is represented by the remarkable "Sutcliffe-Evans" process. In the latter case the coal is roughly pulverized and mixed with about twenty per cent coke breeze. It is then briquetted without any binder in high pressure briquetting presses under 10 tons to the square inch, and these "pure coal" briquets are then carbonized at a comparatively high temperature to say 1650 deg. F. by internal heating. The residual fuel is, strictly speaking, not a low temperature product at all, as it contains only two per cent volatile matter, but it has some remarkable properties in that it is entirely free burning. In fact it closely resembles charcoal both in appearance and texture, it will light just as easily as coal, and burns smokelessly, with a high emission of radiant heat. This process has also proved that it is not necessary, in order to obtain a free burning smokeless fuel, to have a product containing ten per cent volatile matter. The carbonized briquettes so obtained are extraordinarily hard, much more so in fact than metallurgical coke, and some important results are expected with regard to the application of this fuel to the blast furnace in replacement of metallurgical coke.

Vertical Retort Processes

There are of course many other processes, for example, the "Everard-Davies," "Freeman," and "McLaurin" in Great Britain, and the "Laucks-Green" and "Wallace" processes in the United States, which all use vertical retorts, although they otherwise have nothing in common. Two of the most recent adaptions, apart from the use of a lead bath, are pulverized coal and a combination of low temperature carbonization for the firing of water-tube boilers.

With regard to water-tube boilers, there is being developed in Great Britain—and characteristic of this also is the "Pintsch" process in Germany—the idea of passing the raw coal on the way to the mechanical stoker through a vertical cylindrical retort in front of the boilers, in which the coal is carbonized on the low temperature principle either by the highly superheated steam, or the combustion of the low temperature gases evolved. That is to say, the coal, en route to the boilers, is carbonized and the valuable low temperature oils, together with the sulphate of ammonia, extracted, while the residual low-temperature fuel travels on and is burned continuously in the mechanical stoker. At the same time any residual gas is also burned over the stoker.

A further important development in connection with the economical use of coal, which is of course not strictly associated with low-temperature carbonization, is the hydrogenation of coal; that is to say, the conversion of it bodily into liquid products, as represented chiefly by the remarkable work of Bergius in Germany. Altogether, we are fortunately beginning to approach a period when in the very near future it will be regarded as criminal to burn raw coal at all.

A Devilish Good Scheme—According to the *Deseret News*, the Utah By-Products Co. is going to treat coal by subjecting it to the action of steam superheated to some 800 deg. F., driving off the volatiles into a system of separators by which, through "diabolic" expansion, the byproducts are taken off, each in its natural fraction.

Automatic Starters for Synchronous Motors

Frequency-Relay Type

TWO types of starters are described, one for starting on full voltage and the other for part voltage. A frequency relay is used to close the field switch at the proper time.

SYNCHRONOUS motors have for the most part in the past been started with some form of manual starter, automatic-starting equipment being used only to a very limited degree. For engineering and economic reasons there has been a growing tendency to equip other types of motors with automatic starters. One of the reasons has been to eliminate the human element in starting the motor and provide some starting device that would function automatically in accordance with the load conditions to which the motor is subjected, thus preventing the motor or starter from being abused. If automatic starting is desirable with the comparatively simple types of direct-current and induction motors, it is even more so with the synchronous type with its more complicated starting procedure. However, only recently has this problem been given serious attention, even if the use of synchronous motors has been increasing rapidly. If present developments are an indication of what the future holds, then it will soon be just as common practice to start this type of motor automatically as any other.

One of the products of this comparatively new development in automatic starters for synchronous motors

FIG. 1 — FULL-VOLTAGE TYPE AUTOMATIC STARTER

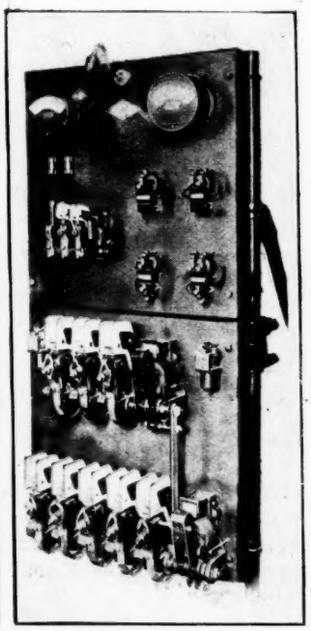


FIG. 2 — REDUCED-VOLTAGE TYPE AUTOMATIC STARTER

is that brought out by the Electric Machinery Manufacturing Co., Minneapolis, Minn. In starting a synchronous motor one of the problems is to close the field switch at the right time, something that no operator can do with a manual starter. In this new type of starter, after the first starting impulse is given by a push button, float or pressure switch, etc., the function of the starter is controlled by a frequency relay connected in the field circuit. This relay is actuated by the induced current of decreasing frequency in the field circuit during the starting period.

When an alternating voltage is applied to the stator terminals of a synchronous motor at standstill, a current flows in the winding, producing a voltage in the

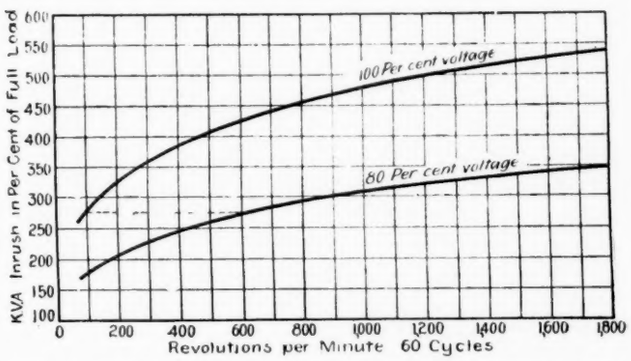


FIG. 3—SYNCHRONOUS-MOTOR CURVES SHOWING KVA. INRUSH AT STARTING ON DIFFERENT VOLTAGES AND SPEEDS

field coils of the same frequency as that of the line; that is, in a 60-cycle motor the field-circuit frequency at standstill is 60 cycles and in a 25-cycle motor the field-circuit frequency at standstill is 25 cycles. This voltage in the field winding is produced by transformer action between the stator and field windings, similar to the action between the primary and secondary of a transformer. As the motor increases in speed, the frequency of the field circuit decreases until at synchronous speed it becomes zero, as also does the induced voltage. By arranging the connections so that the field circuit is closed during the starting period through a suitable field-discharge resistance, a current flows in the field circuit that has a decreasing frequency as the motor gains speed, and at synchronism this current dies out completely. This characteristic provides a definite means for actuating the controlling relays with relation to the speed of the motor during starting, without reference to the load or the time it takes the motor to come up to synchronism.

Two Types of Starters Supplied

These starters are supplied in two types: (1) The full-voltage type, Fig. 1, for connecting the stator winding directly to the line at the start and automatically closing the field switch when the motor approaches closely to synchronism; (2) the reduced-voltage type, Fig. 2, for connecting the stator winding first on reduced voltage and after the motor has accelerated to a predetermined speed (40 to 80 per cent of normal) to transfer the stator winding automatically to full voltage and then when the motor has approached closely to synchronism to close the field switch automatically. The reduced voltage for this type may be obtained from an

auto-transformer or in special cases from the transformers supplying the power to the installation.

Contrary to what may be generally known, a slow-speed motor may not take any greater inrush current when starting on full voltage than a high-speed motor will take when starting on partial voltage. This is clearly indicated in Fig. 3, by the dotted line, which shows that a 100-r.p.m. motor starting on 100 per cent voltage takes about the same inrush kva. as a 600-r.p.m. motor on 80 per cent voltage. This characteristic of slow-speed synchronous motors justifies the recommendation that they be started on full voltage, thus simplifying and reducing the cost of the starter. While the synchronous motor starts as an induction motor, the principle of operation is quite different in the two machines. In the synchronous motor the squirrel-cage winding is not active except during the starting period before coil *C* has had time to close contactor *FC*, frequency relay FR_2 closes and opens the circuit of coil *C* and prevents closing of the field contactor until the proper time.

As the motor comes up to speed, the frequency and voltage decrease in the field circuit and the current decreases through coil FR_2 until, when the rotor has reached near synchronism, the relay allows its contactor to drop open and close coil *C* circuit. This coil, thus energized, closes contactor *FC*, as in Fig. 6, which applies direct current to the field of the motor and it pulls into step. When the field contactor closes, it opens auxiliary contact *B* and interrupts the discharge-resistance circuit. Attention might be called to the fact that although the voltage decreases in the field circuit as the motor comes up to speed, the current remains practically constant owing to the frequency

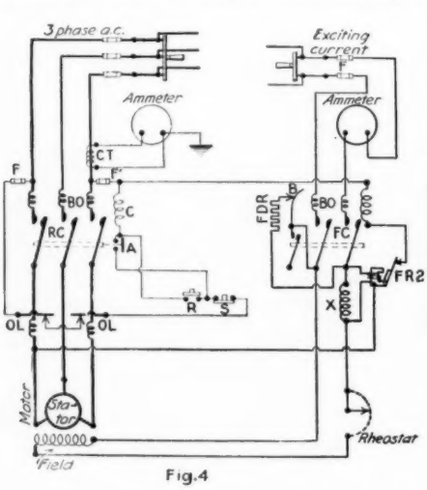


Fig. 4

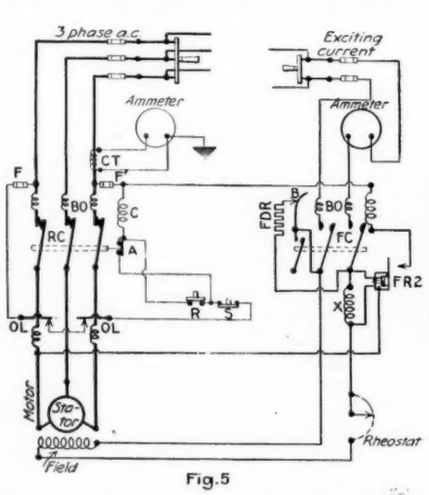


Fig. 5

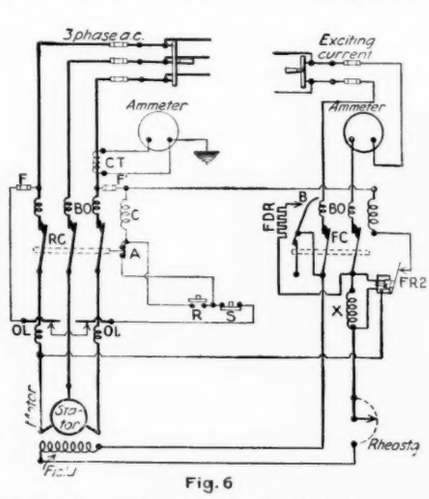


Fig. 6

FIGS. 4 TO 6—WIRING DIAGRAMS OF FULL-VOLTAGE AUTOMATIC STARTER FOR SYNCHRONOUS MOTORS

when the motor is running below synchronism. This makes it possible to design the squirrel-cage winding of the synchronous motor so that the starting current is much less than it would be on a squirrel-cage induction motor of corresponding rating and speed. It is therefore possible in many cases to start a given synchronous motor on full voltage without taking any larger kva. than an induction motor of corresponding speed and rating will take on 80 per cent of full voltage.

Fig. 4 shows the wiring diagram of a full-voltage type of starter arranged for the initial starting and stopping impulse to be given by a push button. When push button *R* is closed as in Fig. 5, a circuit is completed through fuse *F*, the contacts of overload relays *OL*, stopping button *S*, starting button *R*, closing coil *C* and fuse *F'* to the other side of the line. This energizes coil *C* and causes it to close contactor switch *RC*, as shown. When switch *RC* closes, it also closes auxiliary contacts *A*, which shunt push button *R* out of circuit and allow it to be released and the switch remain closed. Closing switch *RC* energizes the stator winding and an alternating current is induced in the field-winding circuit, which flows through reactor *X*, the field-discharge resistance *FDR* and back to the field winding. The voltage drop across reactor *X* is sufficient to cause a current to flow through frequency relay FR_2 and cause it to close. When contactor *RC* closed, a circuit was established through the field contactor closing coil *C*, but the time lag in the coil is longer than for the frequency-relay coil. Therefore, decreasing. However, the characteristics of the frequency relay and reactor are such that the current decreases in the former's coil and increases in the latter as the frequency decreases.

Fig. 7 is an oscillograph record of the line voltage, the stator current and field current of a synchronous motor during starting. The bottom curve is line voltage, the middle curve the stator current and the top curve the field current. The line switch is closed to the stator at *A*, and it can be seen that the current induced in the field coils at this instant has the same frequency as the stator current. As the motor increases in speed, the frequency of the field current decreases, up to point *B* where the frequency is nearly zero, the motor's speed being near synchronous. The induced field current dies down to zero and the frequency relay on the starter actuates the field contactor switch and applies the exciting current at point *C*, causing the motor to pull into step at *D*.

Two frequency relays are used on the reduced-voltage starter. The first is so adjusted that it acts when the motor has reached the desired degree of acceleration, considerably below synchronism. The frequency relay is designed to act over a range of from 40 to 80 per cent of normal speed. When once adjusted, the relay will function at approximately the same speed each time the motor is started until readjusted for some other speed. The second relay is adjusted to act when the motor speed approaches closely to synchronism, and closes the field contactor. Thus by the use of these

two frequency relays the timing of the transfer from reduced to full voltage and the applying of excitation is governed by the acceleration of the motor.

Fig. 8 shows the wiring diagram for a reduced-voltage starter with an auto-transformer. When push button R is closed, a circuit is completed for closing coil S' on starting contactor SC through fuse F, overload-relay contacts OL, coil S', push buttons R and S, to fuse F' and the other side of the line. Energizing coils S' closes the starting contactor and applies reduced voltage to the motor through the auto-transformer. Applying current to the stator causes a current to be induced in the field circuit which closes frequency relay FR_2 as in the case of the full-voltage type, Fig. 4. When relay FR_2 closes, it completes the circuit for frequency relay FR_1, which is connected in parallel with the section of field discharge resistance RS. At the high frequency there is not sufficient current flowing through coil FR_1 to close the relay, so it remains open until the motor has accelerated to the speed corresponding to the rotor frequency for which the relay is adjusted, when it closes. Closing of relay FR_1 completes a circuit for coil C of relay CR from fuse F through coil C, contacts on relay FR_1, push button S and fuse F' to the other side of the line. When relay CR functions, it closes its two upper contacts and opens its bottom contact. Opening the bottom contact interrupted the circuit of coil S' and the starting contactor opens. Closing the upper left-hand contact of CR completes the circuit for coil R' of running contactor RC, from fuse F through coil R', left-hand contact on CR and fuse F'. This energizes coil R', which closes contactor RC and applies full voltage to the motor, causing it to accelerate nearly to synchronism. The upper right-hand contact on relay CR, when closed, provides a circuit through coil C without passing through frequency relay FR_1. This circuit, instead of passing through FR_1 contactor, is through coil C and right-hand contact of CR, stop button S and fuse F', which allows FR_1 to open without interfering with the operation of the controller. When the motor has accelerated to near synchronous speed, relay FR_2 opens and closes its bottom contacts, which completes the circuit for the closing coil on field contactor FC. This circuit is from fuse F directly through the contactor's coil B, the bottom contacts on relay FR_2, the left-hand contact on relay CR and fuse F'. Energizing the coil on contactor FC causes it to close and apply direct current to the field coils as the motor pulls into step. Stopping of the motor is done by simply pressing stop button S, which opens the circuit of coil C.

On the field switch there is an auxiliary contact that is open when the main contacts are closed and vice versa. It is important that this auxiliary contact be closed when the main contacts are open, since it completes the field circuit through the discharge resistance for the current to operate the frequency relay. It is equally important that the contactor closes and completes the field circuit to prevent high voltage being generated in the field winding, which might cause insulation failures. It is necessary that the auxiliary contact open when the main contacts close, so as to prevent connecting the field discharge resistance across the excitation circuit. The field-discharge resistance should be carefully chosen for each motor, as it has a marked effect on the starting torque of the motor, but it has no effect on the functioning of the frequency relay.

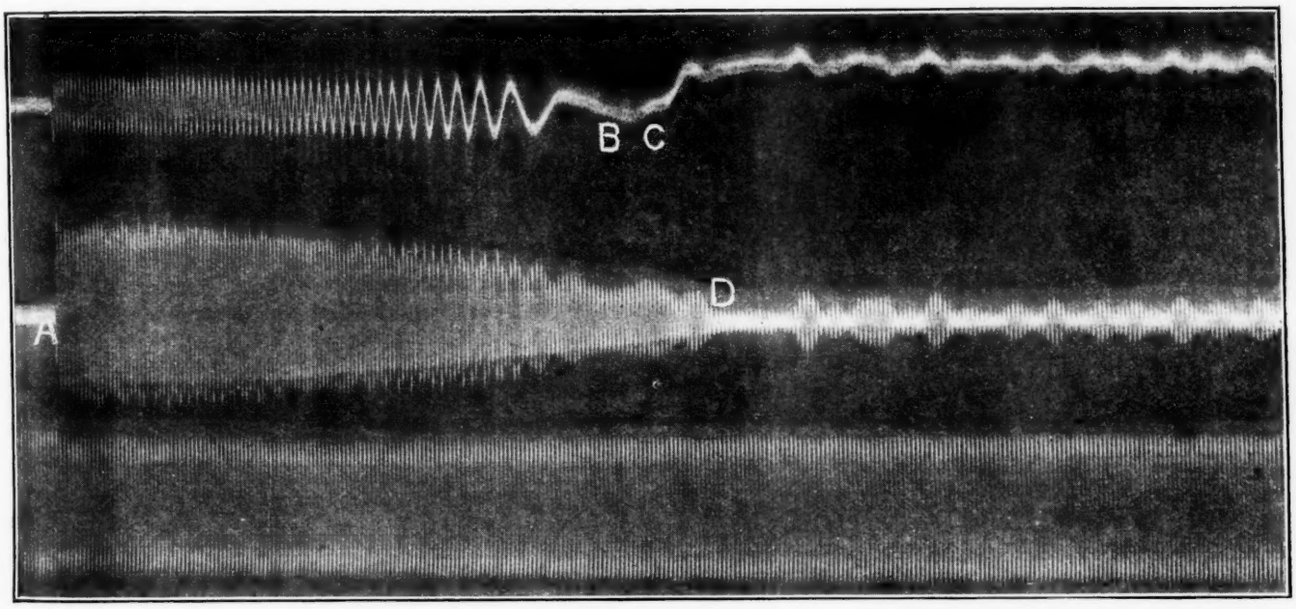


FIG. 7—OSCILLOGRAM SHOWING HOW AUTOMATIC STARTER FUNCTIONS WHEN STARTING A SYNCHRONOUS MOTOR

When starting under light or medium loads, the synchronous motor is capable of pulling into step with little difficulty. Under heavy loads it is desirable to close the field switch at an instant so that it increases the torque of the motor and assists it to pull into step if it is not already in synchronism. For such cases as heavy starting duty a polarizing coil is provided on the frequency relay controlling the field contactor. This coil will cause the frequency relay to act only when the rotor is in the correct relation to the stator to give forward torque when the field poles are magnetized by applying excitation to the field winding.

In many cases it is desirable to unload a motor during starting, and when the nature of the load is such that this can be done, the synchronous motor may be applied to drives for which it could not otherwise be

used. For such applications the unloader circuit may be controlled by the frequency relay, so that during the starting period the load is removed from the motor and when the motor is in step the load is automatically applied.

Overload relays are provided with either automatic or hand resets, according to whether they are used with a push-button actuated starter or with a starter controlled by a float switch, pressure switch or similar device. Low-voltage release is accomplished by the

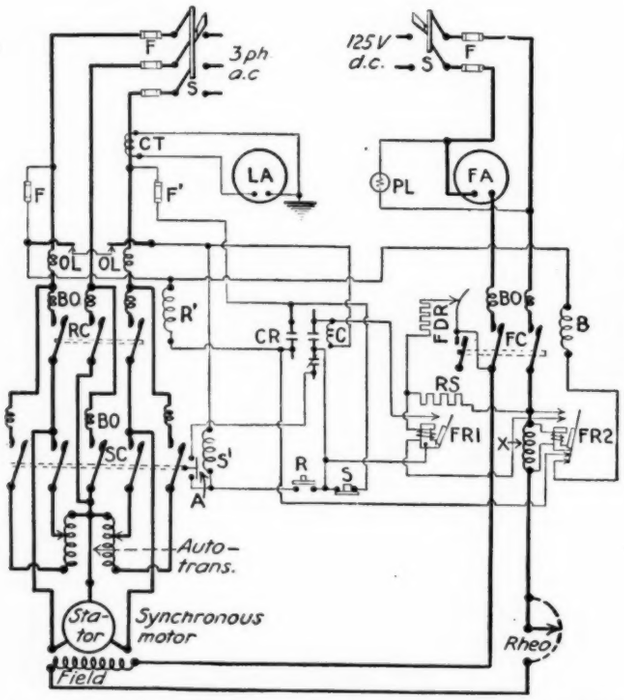


FIG. 8—WIRING DIAGRAM OF REDUCED-VOLTAGE AUTOMATIC STARTER FOR SYNCHRONOUS MOTOR

falling out of the main magnetic contactor when the line voltage fails. These contactors will open when the voltage drops to about one-half normal value.

Should the motor drop out of step for any reason, the field current will be cut off by the frequency relay closing and opening the field contactor when the motor's speed is approximately 5 per cent below synchronism. The field contactor will remain open until the motor attains a speed where the frequency relay opens and closes the field-contactor circuit.

The actuating current for these starters up to 600 volts and in sizes up to approximately 1,500 hp. is single-phase alternating current taken from the power circuit at 220, 440 or 550 volts as the case may be. For higher-voltage circuits the actuating current should be taken from the power system at 220 volts through a small single-phase transformer.

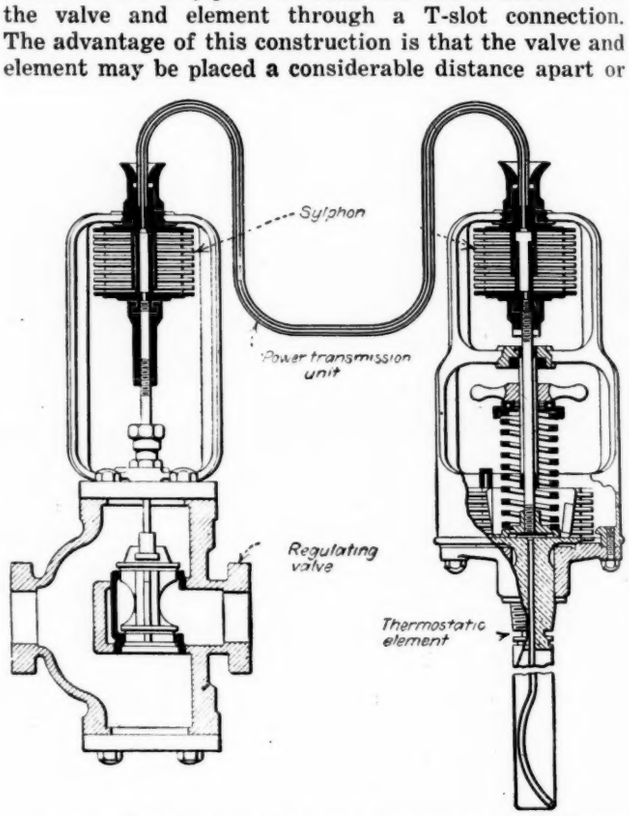
These starters can be used with any practical source of excitation without change in design. This applies to practically all starters up to 1,450 hp. in the standard voltage actuated by alternating current. In some of the large low-tension starters, which are rarely required, it is necessary to use direct current for actuating the contactors. This requires a source of direct current to be available before the synchronous motor is started. In this case it is necessary to use either a motor-generator set exciter which can be started before the synchronous motor is started, or in case the synchronous motor is provided with a direct-connected or belted exciter, a small motor-generator set for furnishing direct current to actuate the contactors may be used.

These automatic starters have been built in sizes up to 1,000 hp. for starting wood grinders in pulp mills. An 800-hp. 450-r.p.m. motor connected to a flour mill through a magnetic clutch is brought up to synchronous speed in about 15 sec., after which the clutch is energized automatically from the starter and the motor picks up its load.

Sylphon Temperature Control Instrument

A recent development of the Fulton Co., Knoxville, Tenn., is a new temperature-control instrument shown in the illustration.

It consists essentially of three parts: a regulating valve, power-transmission unit and a thermostatic element. The regulating valve is installed in the steam supply line and the thermostatic element in the tank or heater in which the temperature is to be controlled. They are then connected by means of a flexible tube that is fitted with a sylphon on each end and is attached to the valve and element through a T-slot connection. The advantage of this construction is that the valve and element may be placed a considerable distance apart or



REGULATING VALVE AND THERMOSTATIC ELEMENT ARE CONNECTED BY FLEXIBLE TUBE

in a rather inaccessible position, the transmission unit being made any desirable length to suit installation requirements. The transmission unit is filled with a non-freezing liquid, and power is transmitted by liquid pressure between the two sylphons. By adjusting the spring on the thermostatic elements, the temperature can be changed to any desired value. The metallic sylphon bellows forms an essential part of other Fulton products, including air valves, damper regulators, temperature regulators for control of air and liquids.

Correcting Vibration in Reaction Type Turbines

By L. LONG*

CORRECTING turbine vibration requires skill, care and experience. This is seldom necessary with the standarized manufacture and installation of the present time. The engineer is better fitted to keep his plant in good condition by a knowledge of the subject. It is well to realize the importance of consulting the manufacturer, and of avoiding the risky work where special difficulties are encountered, as well as to use his judgment in seeing that repairs are carefully made. Power would be glad to have further discussions on the subject for publication.

THE principal causes of vibration in small or medium-sized reaction turbines which are equally characteristic of other types, are: (1) Misalignment; (2) coupling trouble; (3) unbalance; (4) improper meshing of gears; (5) internal rubbing; (6) sprung shaft; (7) rubbing of glands. The location of the causes of vibration and their correction, in steam turbines, is ordinarily the work of a trained man, who has had experience with similar types of machines under different circumstances. There are, however, often, minor causes which may be determined by the operating engineer and corrected. Where rebalancing or alignment is concerned, it is advisable to proceed with caution. Manufacturers should be consulted where special troubles are encountered. The plant engineer who has a knowledge of the causes of vibration and knows how to determine them is in a better position to correct operating troubles himself and to see that his plant is put in proper shape than where the engineer's duties are supposed to be confined to the starting, operating and stopping of a turbine set.

Checking a Sprung Rotor

When it is desired to determine the cause of vibration of a turbine unit, the personal judgment of the engineer or of an experienced erecting man may be sufficient to locate this from the symptoms and characteristics of the vibration taking place. However, the engineer is interested not only in making guesses as to the causes, but in being able to locate them definitely and prove their existence. In such a case the first operation is ordinarily to look for mechanical troubles, such as sprung spindles or misalignment.

If a sprung shaft is responsible, such a condition may be visible to the eye and easily observed. However, in order to make sure, use a micrometer dial test indicator at both ends of the turbine and generator shafts to check how much they run out of true. If a sprung condition is shown, the rotor in question should be indicated as near the middle, between bearings, as possible so as to obtain the measurements of the maximum spring. Ordinarily, machined surfaces should run true with a variation of not more than 0.003 in. or 0.004 in. on an indicating micrometer. If the shaft is bent, it may be possible to place this element in a lathe and indicate at various points for a more accurate location of the spring. If there is no lathe large enough, it often happens that the tailstock of a lathe may be blocked up together with the head, so as to swing the rotor. This may be straightened in a lathe by applying hammer blows through a soft block, or bolt pressure, if it appears to be the best course rather than resort to the repair service of the manufacturer. Peening is always unsatisfactory, chiefly because it leaves the metal in a highly stressed condition, likely to result in further distortion when put back into service. When straightened by bending, the shaft should always be bent in the opposite direction, in amount equal to the original bend and then brought back straight, so as to produce, as nearly as possible, uniform stresses in the metal. Block up solidly at each journal, and remove the lathe centre before applying bending force. In most cases the responsibility for such an operation should be avoided by the engineer and placed with the manufacturer's representative.

A turbine set may be in correct alignment, yet be subject to vibration due to improper conditions of the coupling, such as eccentric or sprung flanges. It will be found a common practice to separate coupling heads with a cold chisel. This should never be done, for if the machined face is burred, then you cannot tell what you are doing when aligning with the solid couplings; if a burr is made on the face of it, it is impossible to bolt it up as it should be. The coupling flanges will not be in line, or parallel. In three-bearing turbine sets, with rigid couplings, this will prevent the plug and recess fit or, in other words, the centering fit, Fig. 1, from bringing the centers of the shafts concentric. This last-named cause is more or less common in three-bearing turbines. When a condition of this kind is found, it is impossible to make the turbine run smoothly, and no amount of balancing will cure the trouble. The roughness will be felt in the generator shaft at the turbine end or at the outboard pedestal end. If you balance the trouble out of the turbine end it will appear in the outboard end, and if you balance it out of the outboard end it will appear in the turbine end.

Check Trueness of Coupling Flanges

By examining Fig. 1, it will be seen that if the centers are not brought exactly together by the centering fit, the turbine shaft being fixed in its position by the two bearings, the generator shaft center must revolve around it. When the turbine gets up to speed, centrifugal force will be great enough to throw the whole generator shaft, giving it a spiral effect, which will show heavy markings that are confusing in the extreme.

Misalignment at the couplings is a frequent cause of troubles of this kind. Coupling flanges, whether the

*Consulting Engineer, Muscle Shoals, Ala.

coupling is of the flexible or the rigid type, should be aligned so that they are practically central and parallel under conditions of load. (This subject has been discussed at length in previous issues of *Power*.) Undue misalignment in a flexible type coupling will result in excessive wear of the rubbing parts with possible vibration. In the rigid type coupling, however, vibration or heating of the bearings is the usual result. It is not sufficient to use a straight-edge in aligning solid-head couplings, but use inside micrometers or feeler gages and block gages. Always use a dial test indicator on the

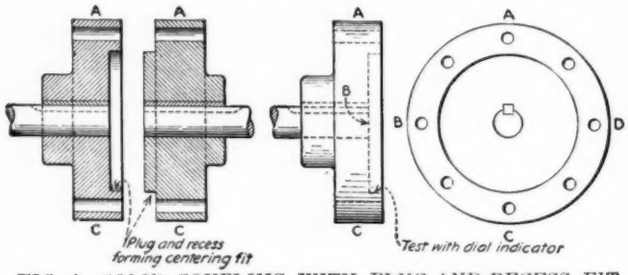


FIG. 1—SOLID COUPLING WITH PLUG-AND-RECESS FIT

face of the coupling to find if it is true, whether it is a solid-head type or a semi-flexible or flexible type. If a pin type is used, the heads or main flanges will be far apart enough to use inside micrometers. Remove the sleeve. It may be necessary to lift the generator field and slip the sleeve from the head. Take a straight-edge and place on the head extension (not flange of the head), Fig. 2. Bring the flanges central by placing the straight-edge at four points around the head. This may be done by removing the shims from under the bearing pads of the generators and adjusting them as they should be. Do not change the shims on the turbine end; to do this will change the clearance of the blading, which would be the worst of errors.

Mark both flanges of the coupling in four places and with the micrometer dial test indicator on the inside of the face, Fig. 2, make the following measurements: First, turn the turbine and generator over at least three times, taking readings so as to make sure you get the same readings each time. In turning over, the dial test indicator may read as follows: At *A* plus 0.002, at *B*, minus 0.001 at *C*, 0.000, at *D*, 0.000 in. for the turbine end, and on the generator end, at *A*, plus 0.001, at *B*, minus 0.003, at *C*, 0.000, at *D*, 0.000. You will see that in using the inside micrometers, when the two *A's* are opposite, the micrometer must not read the same as at *C* or *D*, but must read 0.003 less than true, and if the two *B's* are opposite it must read 0.004 more. The ratio of radius of the coupling, to the distance from the coupling to the outboard pedestal bearing being, say, 1 to 20, if the micrometer reads the same all the way around the outboard bearing will be out of line at *A*, 20 $\times$ 0.003 or 0.060 in., and at *B*, 20 $\times$ 0.004 or 0.080 in.

Prevent End Play When Using Truth Indicator

It perhaps should be pointed out that the use of the truth indicator on the face of the coupling flange will give results only when the rotor is in the lathe or in some manner restrained from moving endwise. In the flexible type coupling truth of these faces is not essential to proper alignment and proper operation of the coupling.

In aligning, it is quite desirable that the small diameters of the coupling heads, Fig. 2, upon which the straight-edge is placed, be of uniform diameter, so that a satisfactory reading can be obtained. It is possible to substitute for the straight-edge a truth indicator or arm with test dial attached to one side of the rotor and set to contact against the circumference of the hub of the other coupling half; then by revolving both shafts at the same time and taking readings, the two shaft ends can be accurately adjusted to the same center.

In adjusting the straight-edge alignment, move both ends of the generator at the same time; in aligning to the micrometer, move only the outboard end. Fig. 2 shows where to place the straight-edge on a pin-type coupling. Get the coupling in line with the straight-edge first, and each time the outboard pedestal bearing is moved, check with straight-edge or truth indicator for trueness, before using inside micrometers. In bolting up flanges of rigid types, Fig. 1, see that no burrs are on the inside faces.

Another Method of Checking Alignment

This alignment, when finally completed, can be checked by another method. This does not require the truth indicator to be used. Both coupling heads should be marked so that they can be rotated and still kept in the same relation to each other; then by means of the inside micrometer measurements should be taken of the distance between the faces of the coupling heads, as shown in Fig. 2, at top, bottom and each side; then *both* rotors should be turned exactly 180 deg. and reading again taken at the same points. From these readings the outboard bearing can be set so that the shaft ends at the coupling heads are parallel with each other even though the coupling faces upon which the readings are taken, are not quite true. Obviously, the outboard end of the generator shaft will be high to the extent required by a reason of deflection of the shaft.

Geared turbines should have the couplings checked with straight-edge for central and block gages used between the machined shoulder on the main gear and the pinion gear for parallel condition.

Large units should be checked at least twice a year for alignment, as the foundations are quite likely to

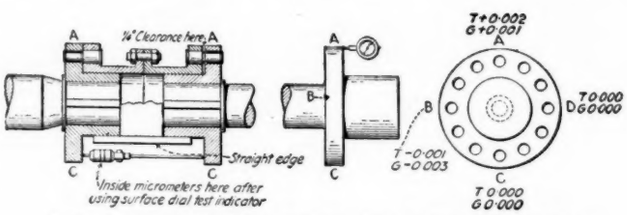


FIG. 2—OPERATIONS WITH PIN-TYPE COUPLING

settle, and a misalignment at the coupling of 0.005 in. may set up a vibration, or a bumping noise may be noticed at slow speed.

Solid-type couplings, Fig. 1, should be aligned by loosening the bolts, slightly separating the flanges, and measuring for a parallel condition. Feeler gages are most convenient. The flanges should also be checked for trueness, warping or burrs as in flexible type.

While the faces of the solid couplings must be very true and free from irregularities of any sort, the use of feeler gages alone, between the coupling faces, will not give sufficiently accurate results, partly because of inability to obtain accurate measurements, but chiefly because this method does not properly compensate for

the change in deflection of the shaft between the bolted and unbolted conditions of the coupling.

In doing such aligning, the feeler-gage method should be employed first to obtain approximate alignment. These measurements should of course, be taken with the coupling end of the single-bearing rotor supported by the spigot fit or centering fit of the coupling. Then the coupling should be entirely disconnected and the weight of the rotor is taken by blocking or some other means. At the outboard bearing of the rotor, which has two bearings (which is usually the turbine or reduction gear), the location of the shaft should be determined both vertically and horizontally by micrometer or pin-gage measurements, taken from the bearing housing, as close to the bearing as possible. Then, the coupling end of the shaft should be supported by means of a spring or weighted lever, which will support the weight that this bearing is intended to support, but will have sufficient freedom to allow the shaft to take any position, sidewise or vertically, within at least one-sixteenth of an inch. Either the bearing or the bearing-supporting pads will have to be removed to permit this freedom.

Test Bolted Rigid Coupling for True Running

Then the coupling should be assembled and the bolts thoroughly tightened, great care being exercised to be sure that the faces of the coupling are thoroughly clean and true. Then, the rotors should be revolved and by means of a truth indicator on the shaft at the spring support, observations should be made of the amount this shaft runs out of truth; if this is more than a few thousandths, it is evident that the coupling is not properly made up and must be corrected. After this has been done, the outboard generator bearing adjustment should be changed as necessary to bring the shaft at the spring-supported end, to exactly the position in which it was when the first measurements were taken, with the shaft resting in its bearing.

The bearing may then be replaced and the spring support removed, and the alignment will be correct, and furthermore, each of the three bearings will be supporting its proper load.

If the gland runners are rubbing the gland cells, it will set up a vibration on the same principle as dampening the finger and rubbing it over a window pane. This may be cured by shimming or machining the gland cells as the case may be. *Do not change the thrust-bearing adjustment* unless you are sure of yourself, as a little mistake here will cause the blading to rub or sideswipe.

In geared-type turbines, if the gears are the cause of the vibration, sometimes it will be found upon examination that the pinions are pressing harder in one place than another. This may be determined by coloring the gears with a solution of muriatic acid, Persian blue, or other suitable coloring, and running them to get markings. Scrape until they press equally all the way around. In one instance I found they would press hard on one side part the way around and then on the other side, showing a slight bend in the shaft. This would give the pinion a violent thrust back and forth, to such an extent that the rotor would rub the nozzles on one side and the reversing chamber on the other, setting up a violent vibration. This was relieved by scraping, which took about a week.

If the governor gears are of the worm and pinion type, the pinion on the governor shaft should have its center ¼ in. above the center line of the turbine shaft and should have about 0.004 in. backlash and press the same on each side of the pinions and worms. Test the governor shaft for trueness by placing a pointer on the frame and near enough to the pinions to use a feeler gage. Turn the shaft, using the feelers between the pointer and each pinion at four points on the shaft.

When the turbine has the cap off, examine the stationary and rotating blades, see that they do not rub the cylinder or spindle, as this will cause vibration.

Vibration due to unbalance can usually be easily distinguished by an experienced erecting turbine man. However, where the engineer is doubtful on this subject or wishes to be in a position to prove that such is the case, it is better first to check other possible conditions as previously mentioned.

The first thing to do is to determine whether the turbine end or the generator end is causing the trouble. One way is to place the hand on the governor end of the turbine. It is much better to make the determination by holding an ordinary pencil point in contact with the shaft adjacent to the bearing, after the shaft has been thoroughly cleaned with emery cloth. In this way a more accurate idea can be gained of the amount the shaft is running eccentric at each bearing.

Determine Whether Vibration is in Turbine or Generator

If very little vibration is felt, try the outboard pedestal. When it is violent, you may find that the generator is causing the trouble. To make sure, uncouple the turbine from the generator and run the turbine alone. The cause is in the generator, or at least from the coupling back, if the turbine shows no vibration. If the turbine shows vibration, and it has an automatic stop governor, remove the control governor, provided this does not interfere with the oil pump, so the turbine rotor will have nothing to disturb it, and run it up to speed by hand control. Make sure that the automatic stop is working, by trying it out two or three times.

Before removing the governor, however, take powdered chalk and mix it with alcohol, and with a very small brush paint lightly the shaft at the coupling end and governor end, also the generator shaft at the outboard end and coupling end. While the turbine is at full speed, with a very hard sharp pencil and with the arm resting on something firm, touch the shaft carefully and lightly. This will give you the markings to determine at which point to put the weights. After uncoupling the generator from the turbine, take fresh markings on the turbine shaft at both ends. In a notebook make a record to show which markings were made before and after uncoupling. Keep an exact record of all moves in balancing; do not trust anything to memory.

With stencils mark the rotor of the generator into at least six division or more, such as *A, B, C, D, E, F*. If the heavy markings on the shaft come under *C* or *D* or any other letter, make a note of it, in case the chalk should get rubbed off by removing the turbine cap or the stator of the generator, or from any other cause.

Having located the cause of the vibration, let us say in the generator, mark the stator with a scribe on each side, with companion marks on the bedplate. Remove the stator and replace the field, recoupling it to the turbine. It is very important that the stator be replaced exactly as found, because if not centered mag-

netically, when the load comes on, the rotor will seek its magnetic center and may rub seriously should it be off. This has been looked after by the erecting engineer, and if no trouble of this kind has developed, it is likely to be right.

Do Not Place Weights Opposite Heavy Markings

If a weight be turned loose from the periphery of a wheel in motion, it describes a line tangent to the circle. Therefore the throw of a weight is not directly away from the center of the axis. So do not place weights opposite the heaviest markings, but about 35 deg. opposite the direction of rotation from the markings. This will give the throw about opposite the heavy markings. There is no set rule for this, but experience has taught us that this is about right.

Another law that must be taken into consideration, but one that hardly ever asserts itself in reaction-type rotors, unless the turbine bearings have become badly worn, is, that if a mass be revolved and unconstrained, it will revolve about its axis of gravity. This sometimes will make the rotor revolve around this axis of mass, and not around its mechanical center; in this case the heavy marking will be on the light side of the rotor.

Around the surface of the rotor or around the rim will be found weights or screws for balancing. Run the turbine to speed, take the markings and move the weights according to the foregoing instructions, until a perfect mark is made entirely around the shaft.

The same thing will apply to the turbine balancing if the trouble is found in it, except this will be a much more tedious job, as the turbine cap will have to be removed every time a weight is moved.

Make an accurate account of every move, so reference may be made to it from time to time. This record should show the number of the trial, the magnitude of vibration, the change of weight, the amount of weight in grams, the letter under which the weight is placed and the letter under which the heavy markings come.

The small turbine rotors have shoulders for chipping, in order to balance. It is best to put the small ones on roller balancing ways and chip for balance until the rotor will not settle to a stop position, and then run for markings and rechip for perfect balance.

An Engineer Investigates the Diesel Engine

Letters passed between two engineers on the subject of prime movers. The chief topic discussed is the initial costs of Diesel engines.

Worcester, Mass., Aug. 15, 1923.

Mr. J. R. Stowe,
Pittsburgh, Pa.

Dear Jim: You will be surprised to learn that we are going to scrap the steam power plant and put in an entirely new outfit of 2,000-kva. capacity. Of course the old machines, although 15 years old, are still in good condition, but while a water rate of 35 lb. a kw.-hr. did not worry us as long as we could get coal at $2.50 delivered and firemen for $15 a week, now that we are paying $6.50 a ton for dirt, the old man has been tearing out his last few wisps of hair every time the auditor shows him the factory cost sheet.

This is especially serious since our product is sold in a strictly competitive market and there is every incentive to a lowering of our manufacturing costs.

This plant is, as you know, in addition to our waterwheel, which was the original source of power, but was increased by the installation of the steam equipment mentioned. Besides the conditions mentioned, the factory is to be enlarged, and the total power requirements will be approximately 2,000 kw. more that the waterwheel can supply.

The ax I have to grind and for which I want you to turn the grindstone takes the shape of deciding upon the kind of plant to recommend.

In the discussion at the executive conference three suggestions have been offered and will be gone into at length before a decision is made. The first proposition is to install a 2,000-kva. condensing steam-turbine plant together with water-tube boilers, stokers, etc. The turbine would be arranged so that steam could be bled at 5 lb. gage, for we will require about 3,600 lb. of steam per hour for process work. I believe that the costs with the 2,000-kw. steam plant would be close to 2½ cents including overhead.

The second plan considered is to purchase central-station power, which with our load conditions can be obtained for approximately 2 cents per kilowatt-hour including a demand charge. As an alternative the old man has suggested that we consider the installation of a Diesel oil-engine plant and use two of the present boilers, which are allowed 100 lb. pressure by the insurance company, to supply the process steam.

It seems that the association to which the company belongs has a uniform cost-accounting system. Our costs are about the average of the others, but the one fellow who undersells us proved it was not a case of taking a smaller profit by flashing a cost sheet which showed among other low items that his power costs are only one-half what ours are. This man has a Diesel plant of three units and has no water power to help him.

Both steam equipment salesmen and central-station solicitors have raised the points that the first cost of the Diesel is very high, that the life of the engine is but 10 to 12 years, which would make, with 6 per cent interest and 2 per cent taxes and insurance, an overhead of 16 per cent. This, so it is claimed, would mean an overhead charge of about 7 mills per kw.-hr. if a 70 per cent load factor is assumed.

The old man is so hypnotized with the Diesel idea that I wish you would give me your views as to the first cost as well as the overhead and operating charges to be expected, as I recall you told me last spring that you folks were investigating the possibilities of the Diesel.

John Haite,
Dodds Milling Co.

Pittsburgh, Pa., Aug. 20, 1923.

Mr. John Haite, Chief Engineer,
Dodds Milling Co.,
Worcester, Mass.

Dear Johnny: Your letter certainly gave me a big laugh. Fancy having the sweet sleep of innocence that is the right of every 60-year old coal heaver like you, disturbed by the nightmares of central-station service and oil engines. Well, John, make up your mind that it is up to a lot of us steam men to get out our lariat and rope the best-looking mare, for ride one of them we must if coal and labor keep on skyrocketing.

Getting back to realities, if the central station offers a rate that, based on the best of estimates, is cheaper than generated power, the proper thing is to sign on the dotted line. But as all of us are more or less prejudiced and to prove our case will usually innocently tint facts accordingly, one should not accept the unsupported statement of the fellow who has something to sell.

While a simple non-condensing steam plant may be purchased for much less than the cost of a Diesel plant, the high operating cost of the former eliminates it from consideration save in exceptional instances. Compared to a condensing steam plant having a coal rate of 2 to 3 lb. per kw.-hr., the Diesel plant is actually cheaper in first cost.

Evidently, the parties you mentioned used comparative pre-war prices as the basis of their computations. Under present conditions, while there has been an increase in steam and electric machinery costs of close to 100 per cent, Diesel units may be purchased today at pre-war prices. Investigation will prove that at the present time Diesel plants ranging from 300 hp. upward can be installed at prices equal to or less than the cost of a steam plant with condensers, superheaters, etc.

It is almost impossible to give price data on Diesels that will prove consistent at all times and places. Engines have been quoted as low as $45 per brake-horsepower and as high as $120. The former applies to units of over 750 hp., while engines of small powers are quoted at the higher price. Bids from the several builders are by no means consistent.

You are, however, interested in total costs including generators, building and all accessories such as oil tanks, pumps, etc. I am attaching a curve covering Diesel costs per kilowatt of installed capacity; this is based on a number of actual bids. It will be noticed that while I stated that the large Diesels have been quoted at $45 per horsepower and the small units at $120, the costs per kilowatt do not have the same ratio. This is due, first, to the fact that only in exceptional cases will the prices per brake horsepower of engines below 750 hp. fall below $65; second, as the engine sizes increase the revolutions per minute decrease and, consequently, the generator costs per kilowatt increase.

Illustrative of the cost of oil-engine plants the following were the contract prices of two Diesel engines installed in the municipal light plant at South River, N. J.:

One 700-hp. engine including a direct-connected 594-kva. generator, generator panel, exciter, and conduit, etc., installed	$61,425.00
Foundations	4,985.00
One 500-hp. engine including a direct-connected 416 kva. generator and exciter	43,300.00
Switchboard	1,075.85
Building and engine foundations	10,000.00
Total	$120,785.85
Cost per kva. capacity	$119.78

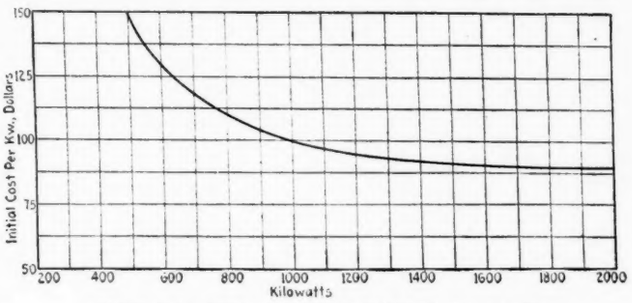
Two Diesel engines were installed in the Crowley, La., municipal plant at a total cost of $79,976.21. The equipment prices were as follows:

One 380-hp. and one 285-hp. Diesel	$46,698.00
Foundations	7,177.31
Two generators, switchboard and exciter	15,329.00
Erection of switchboard	470.00
Building	7,301.90
Total	$79,976.21
Cost per kilowatt	$155.25

I noticed in a recent issue of *Power* that two 1,050-kva. Diesel-generator sets, including building and other equipment as well as certain material not entering into the construction of the Diesel plant, had been purchased for $200,000. This plant figures at approximately $92 per kva. and checks quite closely with estimates I have from several engine builders.

In the past the oil engine has been built in comparatively small capacities in the United States. This was primarily due to the market conditions. Coal was low in price, and at that time the larger steam plants could be built at a smaller initial investment and the difference in operating costs did not offset the difference in the overhead charges. On the other hand, the small steam plants were so inefficient as to make the Diesel attractive even at its then relative high initial cost. It has been only within the last four or five years that any builder has been in a position to offer units ranging from 1,000 hp. upward, and until the operating costs of the larger steam plants became high by reason of increased fuel and labor charges the incentive of developing the larger Diesel was non-existent.

At present engines of 1,000 hp. and over are being built by several firms and patterns, etc., have been



INSTALLATION COST OF DIESEL PLANTS

prepared for units up to 6,000 hp. Such large units can be sold at a total installed price, including all equipment, of about $90 per kilowatt.

In your case I would suggest that prices be obtained on a plant consisting of three 1,000-kva. units. You would then be able under normal conditions to carry the units fairly well loaded. In the event of any engine trouble two units would give you 80 per cent of your anticipated requirements, and since you do not run on Sunday the ordinary adjustment could be made without shutting down the plant.

You see, John, that the initial investment is not excessive and will not exceed your steam-plant estimate. The question of what overhead charge you are to assess against the Diesel plant calls for more time than I can give you today. I will however, sharpen my pencil and let you know the results of my figuring. I would say, however, that this bugaboo of high overhead has prevented many a factory from installing its own plant when in fact a big saving would have been made by such a plant.

With kindest regards,

JIM.

[*The foregoing correspondence, together with several other letters which will be published in future issues, has come into our hands. The points brought out are of such general interest as to make their reproduction of value. Names and localities, for obvious reasons, have been replaced by fictitious ones. Comments on the letters' subject are invited.*—Editor.]

In separating air from steam, it is frequently found that some gases are lighter and some heavier than steam, even at the same pressure and the same temperature.

Operating Hydro-Electric Plants To Obtain Most Economical Output

Method of Keeping Record of Plant Performance To Obtain Best Economy of Available Water — Operating in Parallel with Steam Plants — Obtaining Maximum Output from Hydro-Electric Units

BY RALPH BROWN*

EVEN though there be no apparent need of economical output operation, it is well to study the subject at least sufficiently to be prepared to follow the methods most applicable to a given plant or even a complete generating and transmission system should stream-flow conditions unexpectedly become such as to require economy in the consumption of water. In some instances, owing to failure to store water during periods of high flow, or after unexpected drought, economy in the consumption of water may become absolutely necessary, yet because of lack of time to make proper studies, possible lack of co-operation among those concerned with operation, together with little or no experience in operating under such unusual conditions, a suprisingly large amount of water may be wasted before economical output operation becomes effective. In other instances, owing to the absence of complete operating records, the knowledge obtained during one period of economical output operation has been largely forgotten before another period of deficient stream flow, occurring probably many months later, has made economical output operation again necessary.

Economical Output Data Sheet

Assuming that data are available from which the discharge through the turbines, discharge over the dam and storage capacity of the forebay may be computed, or preferably, that these values may be taken directly from tables or curves, an economical-output data sheet similar to that given herewith may be made up to apply to any hydro-electric plant, and when the items called for are entered thereon, a valuable record of station operation is made available. The form has been devised for use where an accurate record of operation during periods of low flow is required, but with slight changes it may be used to record station performance at any time, assuming, of course, that the stream flow and station draft are known. Most of the items listed are self-explanatory, the figures given being based on the performance of a station containing four 11,000-kva. generators driven by reaction turbines, the station output being transmitted over two 110,000-volt circuits to one main substation. Item *E*1, transmission loss, is the sum of the losses occasioned by the step-up and step-down transformers and the transmission line. If watt-hour meters are connected between the low-tension buses and the low-voltage windings of the transformers at the generation station and the substation, item *E*1 can be obtained from the meter readings; otherwise it should be computed for each hour by adding the transformer losses to the line loss, the total for 24 hours being the transmission loss.

The average head *I* is 110 ft., being increased to this value from the normal head of 108 ft. by 2.5-ft. flashboards. The leakage through the flashboards *D*4 is 75 cu.ft.-sec., and since the outflow corresponds to the inflow, the forebay level was maintained constant 0.5 ft. below the top of the flashboards, thus closely approaching the ideal elevation, which should be maintained just low enough to avoid spilling water. The

ECONOMICAL OUTPUT OPERATION SHEET*

Date..... .....Station

	1	2	3	4	5
	Kilowatt-Hours	Average Kilowatts	Per Cent of Delivered Energy	Average Cu.Ft.-Sec.	Cu.Ft.-Sec. Hours
A. Station light and power	1,200	50	0.190	7	168
B. Local light and power	2,400	100	0.380	14	336
C. Excitation	8,780	366	1.390	50	1,200
D. Leakage through flashboards	13,334	558	2.111	75	1,800
E. Transmission loss	84,750	3,530	13.417	482	11,568
F. Energy delivered to substation	631,650	26,319	100.000	3,597	86,328
Total	742,114	30,923	117.488	4,225	101,400

G. Total a.-c. generation = 720,000 kw.-hr.

H. Average a.-c. generation = $\frac{720,000}{24}$ = 30,000 kw.-hr.

I. Average head = $\frac{2,640}{24}$ = 110 ft.

J. Average discharge through main units = $\frac{98,400}{24}$ = 4,100 cu.ft.-sec.

KG. Generated kilowatt equivalent = $\frac{30,000}{4,100}$ = 7.317.

KA. Standard generated kilowatt equivalent = 7.441.

KD. Delivered kilowatt equivalent = $\frac{7.317}{1.17488}$ = 6.227

L. Total station draft = *C*4 + *J* = 50 + 4,100 = 4,150 cu.ft.-sec.

M. Total flow through station and over dam = *C*4 + *D*4 + *J* = 50 + 75 + 4,100 = 4,225 cu.ft.-sec.

N. Average river flow = *M* ± (storage in acre-feet lost or gained × 0.504) = *M* ± (zero) = 4,225 cu.ft.-sec.

O. Total wattless component = 432,700.

P. Total kva. generation = $\sqrt{O^2 + G^2} = \sqrt{432,700^2 + 720,000^2}$ = 840,000.

Q. Average kva. = $\frac{840,000}{24}$ = 35,000.

R. Average power factor = $\frac{30,000}{35,000}$ = 85.6 per cent.

KS. Standard delivered kilowatt equivalent = 6.154.

S. Economy index = $\frac{KD}{KS} = \frac{6.227}{6.154}$ = 101.22 per cent.

KI. Ideal delivered kilowatt equivalent = 6.354.

KP. Perfection index = $\frac{KD}{KI} = \frac{6.227}{6.354}$ = 98.001 per cent.

T. Efficiency of generating and transmission system = $\frac{F1}{0.085 \times I \times M} = \frac{631,650}{0.085 \times 110 \times 4,225 \times 24}$ = 66.67 per cent.

U. Height of flashboards = 2.5 ft.

V. Percentage of flashboard's length intact = 100 per cent.

*Average in all cases on this sheet is for a 24-hour period.

average main-unit discharge *J* was obtained from discharge-power curves, as was the exciter discharge, and the generated kilowatt equivalent *KG* is found by dividing the average alternating-current generation *H* by item *J*. In this case the generated kilowatt equivalent is high, because the generators were economically loaded. The delivered kilowatt equivalent *KD* is also high, principally because the transmission loss *E*1 was low, for

*The Great Western Power Company.

both circuits were in service the entire day. The standard generated kilowatt equivalent, 7.441 kw., is the kilowatts per cubic foot-seconds which operating records indicate may be obtained under favorable operating conditions on a day of corresponding flow, head, power factor and alternating-current generation. This standard equivalent is used to convert the leakage, item *D*, to kilowatt-hours.

Items *A*1, *B*1, *C*1, *D*1 and *E*1 are considered as losses, since no revenue is obtained from them, but strictly speaking item *D*1 is the only loss, for while leakage might be obviated, at possibly prohibitive expense, the transmission, excitation and local-service losses cannot be entirely eliminated. All losses are expressed as percentages of item *F*1, the energy delivered to the substation.

The average power factor *R*, while rather low, is well within the capacity of the generators, and is computed from the sums of the daily differences of the watt-hour and wattless component-hour meters. One of the most useful items is the standard delivered kilowatt equivalent *KS*, in this case 6.154 kw., since it indicates the number of kilowatts per cubic foot-second that should be delivered under usual conditions of operation. Item *KS* is made about 2 per cent less than the ideal delivered kilowatt equivalent *KI*. The latter is the figure that calculation based on operating records extending over a considerable period indicated as the maximum number of kilowatts per cubic foot-second deliverable if the load distribution among the units was ideal, if all losses were reduced to a minimum, and if the head were maintained at the maximum value on a day of corresponding stream flow, head, power factor and total a.-c. generation.

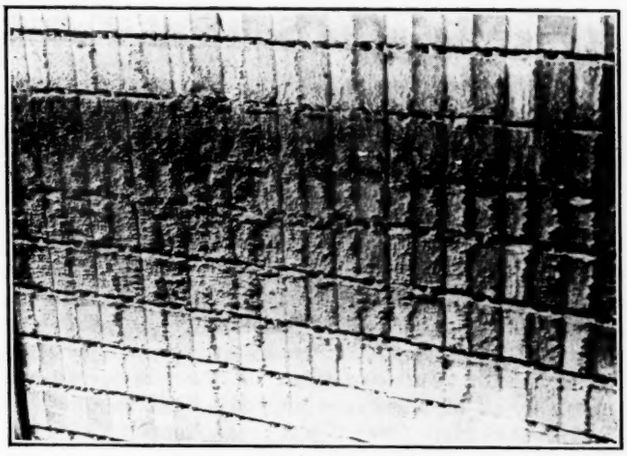
Use of the Economy Index

The economy index *S*, in this case 101.22 per cent, is a direct measure of economical output operation and indicates that the delivered energy was 1.22 per cent greater than the standard for similar conditions of operation. Principally because the total station load is generally such that it is not possible to operate the generating units at such loads that the ideal discharge is obtained, the actual delivered kilowatt equivalent will usually be 2 per cent to 5 per cent less than *KI*, the ideal delivered equivalent, but by careful operation the standard equivalent can frequently be exceeded.

Where systematic efficiency efforts are followed, it will stimulate interest if the economy index, with a brief explanation of any deviation from one hundred per cent, is conspicuously posted daily in the generating station and substation. In view of the fact that the operating revenue may be appreciably increased by well-directed efficiency efforts, the best results will probably be obtained if a percentage of the increased revenue is shared, as a bonus, with the employees.

If the station to which the economical-output operation data apply was operated in parallel with other hydro-electric or steam stations, it would be possible for maximum-output operation to be followed, if the system load were great enough, during periods of high flow. During such periods the hydro-electric station would be operated wide open, and efforts centered on the delivery of the maximum number of kilowatt-hours, regardless of the amount of water used, and any form of kilowatt equivalent is of little importance while maximum-output operation is being followed. A direct measure of maximum-output operation may be obtained, however, by preparing standards for the transmission, excitation, station service and local-service losses, and expressing the energy delivered as a percentage of the energy deliverable, which may be estimated very closely by using the standard losses.

Especially when the operation of the steam plant is not under the control of the hydro-electric station operating department, it will be found that the hydro-electric plant will at times be unable to operate wide open even when the system load exceeds its capacity, and any reduction in energy delivered caused by excessive steam generation should not be charged against the hydro-electric plant. In some steam plants it is not economical to shut down all generating units, because



ACCUMULATION OF DIRT ON FACE OF WATERWHEEL GENERATOR STATOR
Note that ventilating ducts are completely closed.

of difficulties that have arisen due to expansion and contraction strains in the piping; in others units must be kept under steam for stand-by service, and a rapid reduction in the system load may require that steam be wasted if the entire drop, as occurs at noon, is taken by the steam plant. Hence standard values for excess steam generation are usually necessary, and the standard value for a given day should be considered as an unavoidable loss so far as the hydro-electric plant is concerned.

Increasing Rating of the Generators

During periods when wide-open operation of the hydro-electric plant is possible, such losses as those due to heating of the generators, low power factor, and to transmission lines being out of service will cause the greatest reduction in the energy delivered.

If, owing to a high head, as may be obtained from the use of flashboards, or because the generator rating is lower than that of its prime mover, the turbine gates or nozzles cannot be operated wide open, the rating of the generator may usually be increased by attaching fan blades to the rotor, placing baffles on the rotor and stator, and closing openings in the stator frame, so that the cooling air will be most effectively distributed through the stator core and over the winding. Or it may be profitable to install individual blowers, a central system of ventilation, or possibly an air-washer system. Where impulse turbines are employed, the ventilation of the generators can be greatly improved by connecting the stator frames to the turbine housings, thus utilizing the vacuum normally maintained therein

by the out-rushing water to draw air through the generator.

Since the temperature is generally the limiting feature when generators are operated at maximum output. some accurate type of temperature indicator, connected to thermocouples or resistance coils placed in the slots between the top and bottom armature coils, is necessary. And as dirty windings or clogged vent ducts will not only cause decreased generator output because of heating, but greatly increase the possibilities of the occurrence of generator failures, such equipment must be kept clean in any station where maximum or economical output operation is required or where a high standard of service is to be maintained.

Stoker Firing of Sawmill Refuse

The following data are from the records of the Great Southern Lumber Co. at Bogalusa, La., and show results obtained in burning sawmill refuse on a mechanical stoker. The boiler house contains six 6,000-sq.ft. water-tube boilers, eight 1,500-sq.ft. horizontal return-tubular boilers and four 2,240-sq.ft. Scotch marine type. They are provided with direct-connected stacks each about 100 ft. in height above the boiler-room floor. With the exception of the Scotch marine boiler equipped with the stoker, all have the usual type of dutch ovens, fed by spouting fuel through openings in the crown of the arch.

The bulk of the fuel consists of green bark, edgings and slabs, all of which are hogged. This is improved at times by admixture of shavings from the planers, much of which is seasoned wood. The character of the hogged fuel, however, is often lowered by quantities of green dust from saws throughout the mill. Water is frequently run on the main bandsaws when the logs are unusually fat, so that this sawdust upon reaching the fuel house contains considerable water. In the burning of this fuel in dutch ovens three sources of trouble have been encountered.

The fuel accumulates on the grates in large cones which distill a stream of rich combustible gas from their entire mass. This combustible gas is often carried unburned through the boiler before the air admitted through the various openings and through the grates around the base of the fuel cones can be intimately mixed with it. Under the best conditions the intense burning is delayed until the boiler-heating surfaces are actually reached, so that much of the heat goes out the stack in unburned gas and smoke results. The gas is liberated in such quantities that it frequently ignites in the boiler uptake, sending streams of flame up the stack. This is visible evidence of one source of fuel waste. Moreover, because it is difficult to get an early and intimate mixture of air with the fuel, large quantities of air are required, as is evidenced by the low average CO_2.

Another indication of fuel loss is the large quantity of charred fuel carried up the stack and deposited over the mill and surrounding country. This is practically pure carbon and represents the better heat-producing part of the fuel. This charred wood from the stacks is an added feature to the smoke nuisance. It finds its way into the power house and causes many mechanical and electrical troubles.

In the logging of timber considerable quantities of sand and silt are picked up and find their way into the dutch ovens with the fuel. The temperatures inside of the fuel cones are very high, and the sand and certain parts of the ash have been found to fuse and stop up the air openings in the grate, necessitating frequent renewal of the latter. The retarded or secondary combustion causes distortion of the smoke-boxes and of the stacks at their base, which require frequent repairs.

Experiments with hogged fuel extending over a considerable period resulted in data that made the stoker attractive enough to justify a trial with this type of fuel.

The Stowe stoker, which was selected, is primarily a forced-draft, conveyor-feed type for high duty. Natural draft, a large grate area and small air spaces are the requirements for burning hogged fuel. While this stoker is intended for forced draft, the large grate area provided for hogged fuel will give equal capacity on coal with natural draft.

The stoker was installed in one of the Scotch marine boilers which has a shell 9 ft. 6 in. by 13 ft. 11 in. long, with a single 42-in. Morrison furnace and 168 3½-in. tubes. The dryback is brick lined. The stoker has an active grate width of 6 ft. 3⅛ in. and is approximately 10 ft. long, containing 59.7 sq.ft. of active grate surface.

TEST OF SCOTCH MARINE BOILER BURNING HOG FUEL ON STOWE STOKER

Time	Pressures Steam Gage	Draft in In. of Water Breeching	Draft in In. of Water Furnace	Temperatures in Deg. F. Feed	Temperatures in Deg. F. Air	Per Cent CO_2 (Orsat)	Per Cent CO_2 (Dwight)	Averaging Rating During ½-Hour Period, Per Cent
11:00	127	0.64	0.15	162	68	14.5	15.5	184
11:30	141	0.66	0.23	160	69	14.5	13.0	223
12:00	128	0.62	0.22	162	70	13.0	12.0	214
12:30	112.5	0.66	0.29	162	72	12.0	12.0	165
1:00	132	0.64	0.31	156.5	73	11.5	8.0	185
1:30	126	0.62	0.23	158	73	7.5	9	....
2:00	136	0.64	0.20	156	75	15.5	16	146
2:30	135	0.64	0.27	162	75	18	15	224
3:00	124.5	0.59	0.39	161	76	15.5	12.5	204
3:30	135	0.57	0.32	158	76	12.5	9.0	127
4:00	132.5	0.61	0.27	156	75	7.5	6.5	136
4:30	135	0.54	0.25	156	75	11.5	....	117
5:00	128	0.59	0.31	157	75	10	....	117
5:30	124	0.60	0.32	166	73	10	....	117

This gives a ratio of heating surface to grate surface of approximately 38 to 1. The usual draft in the uptake is 0.6 in. and in the rear combustion chamber 0.5 in., but over the fire it is only 0.22 in.

The first five hours of the test, the results of which are here shown, were devoted to burning the average run of fuel from the mill. During the remaining three hours, the stoker was subjected to the severe test of running almost exclusively on green sawdust. The test indicated that the usual capacity secured with the average run of fuel was 150 per cent of rating (frequently exceeding 200 per cent) and 120 per cent was attained with green sawdust.

Owing to an error in construction, which has since been rectified, after the first three hours of operation the furnace became intensely hot and produced an unforeseen condition. The opening between the stoker and the bridge wall had been built smaller than called for by the installation drawings. Exceptionally high temperatures in the furnace resulted in the melting of an accumulation on the bridge wall, and the slag was in such quantities as to stop up the opening between the stoker and the bridge wall. During the removal of this slag the capacities were severely interfered with. Prior to and after this happening the boiler was noted for half-hour periods to develop as high as 220 per cent of rating. Smoke was eliminated, the emission of charred wood for the chimney was suppressed, and there was no sign of secondary combustion. The chimney gases for analysis were taken out of the smoke up-take and analyzed with an Orsat apparatus and checked with a Dwight CO_2 machine.

EDITORIALS

F. R. LOW, EDITOR

Engineering Qualifications

PERSONAL qualities that make for the best all-round engineers have been much discussed by both educators and employers. While such discussions have led to more or less tangible results, the subject still remains largely a matter of opinion. It is therefore illuminating to note what the Westinghouse Electric and Manufacturing Company has to say as a result of several years' experience with the engineering scholarships which it awards annually.

To begin with, only those young men who have shown aptitude for physics, chemistry and mathematics in their preparatory schools are considered. The selection is narrowed further to intelligence, physical qualities and ability to shoulder responsibility. Mental alertness is given greater weight than acquired knowledge, for it is considered that this characteristic is a measure of one's ability to grasp quickly and accurately a new point and retain it. Physical activity is generally accompanied by mental activity and conversely, the sluggish mind is usually contained in an inactive body. Moreover, this company considers that high scholarship is insufficient unless the student also has shown leadership in school activities, for leadership after leaving college will depend largely upon ability to mix and co-operate with his fellow men.

In endeavoring to arrive at any conclusion in a matter of this kind, much depends upon the yardstick used as a measure for the successful engineer. It is true that many men have made material contributions to the engineering profession while little known and receiving small compensation. The abilities of such men have generally shown a one-sided development. But if success is to be measured by influence in the profession and earning capacity, the qualities enumerated are likely to prove most essential. This may easily be checked by reviewing the characteristics of prominent engineers among one's acquaintance.

Low-Temperature Carbonization

IT IS interesting, now and then, to try to guess how fuels will be used for power generation thirty years hence. Frankly, it is easier and safer to guess what will not be done than what will be done. For example, it would seem reasonably safe to say that—barring a few archaic examples to the contrary—the sweltering fireman standing in front of an open firedoor, with a shovel of coal in his hands, will be a thing of the past. But how will it be done?

There are many possibilities. Raw coal may be burned on stokers of the present type or of types yet to be developed. Powdered fuel or producer gas may be used in boilers. Liquid, gaseous and possibly even powdered fuels may be used in internal-combustion engines. In addition, there is the strong possibility that the fuels burned either in powdered or in solid form may not be raw coal, but a residual product obtained by first subjecting the raw coal to a process of low-temperature distillation to remove oils, gases, etc., which are more valuable for manufacturing and the "higher" fuel uses than for burning under boilers. While one would be rash to predict that low-temperature distillation will come in with a rush or that it will do away with all raw-fuel consumption within thirty years, it seems reasonably safe to say that the next few years will see some large-scale developments along this line. Of the many processes that have been invented and tried out recently, some seem to be thoroughly practicable mechanically and either to be commercially successful or to approach very closely to that goal—so closely that a little further effort should insure complete success.

It is true that this matter of low-temperature carbonization is not one of immediate practical concern to the operating engineer. The very nature of the processes is such that the only hope of success lies in exploitation on a large scale. But the engineer is naturally curious about any new developments whose results may later affect his work. He can, therefore, read with interest this issue's article (page 603) on the low-temperature carbonization of coal, in which David Brownlie briefly outlines the various processes and hazards his opinion as to their possibilities. His closing paragraph is particularly suggestive, because he there makes mention of the German experiments which seem to open up the possibility of turning into liquid products not only the volatile part of the coal, but also the fixed carbon.

Where Co-operation Pays

PRIMARILY, power-plant instruments are intended to be useful and give an indication or record of some particular operation in plant performance. A secondary purpose is to be ornamental, but instruments that are allowed to fall into disuse soon cease to be ornamental. If no one thinks enough of these devices to keep them in useful condition, in general they are not considered worth keeping clean. If the engineer so desires, he can obtain equipment that will automatically control almost any power-plant operation or give a record of performance. But such equipment must be kept in good operating condition and the records of performance be intelligently used. A record of the amount of water supplied to a boiler or of steam produced is of little use unless it is combined with a record of fuel fired so as to show the evaporation obtained. These records should be compared daily to check one day's operation against another and detect any falling below a certain prescribed standard. Records of flue-gas analysis, stack temperatures, draft, etc., are of little use unless intelligently interpreted.

Not infrequently, equipment is purchased without due consideration as to how it must be used to get results. If there is not sufficient information on other features of operation to make the new record intelligible, the results are disappointing and the user dissatisfied even if the fault may be his. Or if proper record systems

have not been adopted and maintained, the best results cannot be expected. It is generally recognized among manufacturers of power-plant equipment that one of the most serious problems they have to contend with in many cases is to get the purchaser of equipment to realize on its possibilities. In this respect there is an exceptional opportunity for co-operation between the manufacturers and the users of equipment for better systems of record keeping and a more intelligent use of these records in power plants.

In the final analysis the future business depends not on the amount of equipment purchased at present, but on the results obtained from its use. The user who is getting results, purchases more equipment and influences others to buy. For this reason the manufacturers can afford to give the purchaser assistance to obtain the best possible results from its apparatus. A number of manufacturers are awake to this fact and are working along these lines by furnishing systems of record keeping and cost accounting and having their engineers co-operate with the plant's engineers to improve operation. Many plants already have a highly trained operating force and may not need such assistance, but there are many others where the attendants are not so well trained and it is in these that much pioneer work must be done before modern power-plant appliances can be expected to produce the results for which they are designed.

Corrosion Prevention in the Future

THE confusion still existing among the chemists as to the exact theory of corrosion is necessarily reflected in the thinking of engineers. To understand the extent of this confusion, it is only necessary to recall that some good chemists claim that corrosion is purely a chemical phenomenon, while others are certain that it is electrochemical. In an interesting editorial on this subject the September 21 issue of *The Engineer* throws light on the question from a new angle. It says that while the engineer is fundamentally interested only in practical results, this seems to be a field where a change in the theory is likely to lead to profound changes in practice. That is, if the electrochemical theory is held to be correct, there is naturally a search for extremely pure metals, free from electrochemical differences which could start the corrosion. On the other hand, if corrosion is thought to be purely chemical, attention is naturally directed to the development of satisfactory protective coatings.

However, as pointed out in the editorial, the practical difference is not so great as it might appear at first, because pure metals would not generally be suitable for commercial application. For example, pure carbon-free iron is soft and relatively weak, and it is generally true that metals of the highest purity are not only difficult and expensive to make, but mechanically unsatisfactory and sometimes entirely useless. Therefore, since the abandonment of alloys is unthinkable, the path indicated by the electrochemists cannot, in general, be followed.

The writer of the editorial in *The Engineer* looks forward to a possible solution of the problem in the development of metals that will form (as aluminum does, for example) a natural protective coating. In his opinion, such a coating may also exist in the case of stainless steel, although it is certainly not visible on the brightly polished surface. This suggestion seems to be worthy of careful consideration. The present price of stainless steel may be so high as to make the idea seem ridiculous. Yet it should not be discarded until it is definitely known just what makes stainless steel stainless, and whether, by new methods and large-scale production this quality could be produced at moderate cost. Obviously, the question must be answered by the metallurgists, but the mechanical engineers might well supply the pressure that is so often needed to get the answer to a difficult problem.

Making a Factory Out of the Power Plant

AMONG the most interesting sights to a visitor at a factory engaged in mass production are the automatic features of the machine tools. It would seem that these machines have an intelligence all their own and that the vast hive of human attendants are engaged solely in feeding the raw material into the hungry mouths of the huge forges or presses and in removing the finished product spewed out on the assembly floor. Try as they will, the men never seem to accumulate a surplus of raw material nor can they do more than remove the product when finished; always the insistent call of the machine keeps man at his work.

In the old days of the artisan a job was dallied over and rebuilt a score of times before passed as complete; manufacturing costs were as a consequence high, even though wages were absurdly low. The introduction of automatic machine tools eliminated the human-control factor and costs dropped to heretofore undreamed of values. It is often assumed that these lower costs were due to mass production, but in most instances the reduction can be traced to the elimination of the worker's control over the rate and method of manufacture.

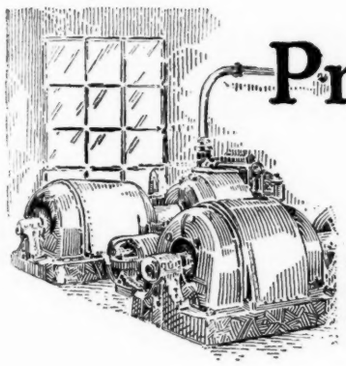
The power plant of the present day may well be compared to the old-time hand-process factory. The entire operation of the plant is directly under human control. What efficiency the plant may possess may be, in theory, limited by the type of equipment, but in fact the efficiency is determined by the character of the operators.

The elimination of human control is the basis for the several systems of automatic control, which are to make the furnace conditions depend upon the steam requirements and each variation in turbine output to change the boiler-room rate of combustion automatically.

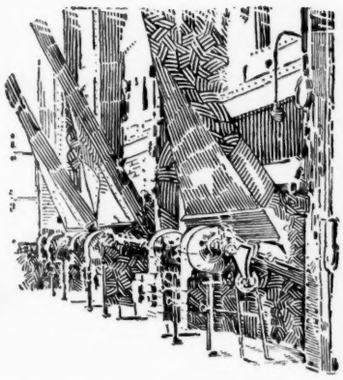
That automatic control of plant efficiency is possible is proved by the internal-combustion engine. This prime mover, especially the oil engine, has its operating efficiency definitely fixed by the design. Nothing that the operator can do will materially change the amount of fuel required per kilowatt-hour. As long as the machine is in such mechanical condition that it will function at all, the number of pounds of oil required can be predicted with a probable error of less than five per cent.

It is this constancy of results, with the elimination of the human factor, that entitles the internal-combustion engine to be given most serious consideration wherever power is required.

Plans are being made to ship Welsh coal to New England if the anthracite operators and dealers persist in "passing the buck" to the public. A little competition of this sort would probably prove more effective than all the legislation contemplated.



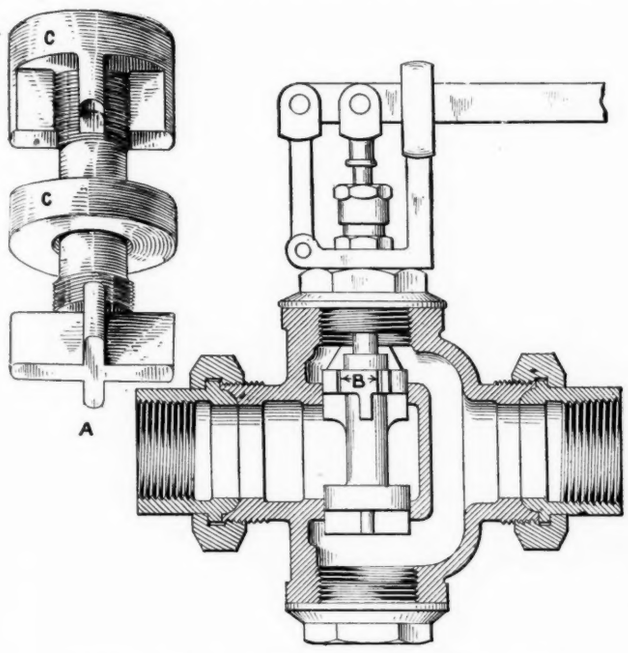
Practical Ideas *from* Practical Men



How Reducing Valve Was Repaired

A reducing valve of the balanced piston type, as shown in the illustration, was used to regulate the pressure of the steam to the oil burners. The regulation gradually became worse until finally the valve had no effect at all. It was then dismantled and it was found that the seats were so badly cut, as at *B*, that enough steam leaked by to cause too much pressure, even when the valve was closed. Some of the grooves were $\frac{1}{16}$ in. deep. A quick repair was desirable as we did not wish to wait for parts from the factory.

The repair was made as shown at *A*. The ends were turned down on the lathe until they were smooth, and then some fine threads turned on them. The seats in the valve body were turned out smooth. Then bushings *C* were made up of the best brass available and screwed



VALVE WAS REPAIRED BY SCREWING BRASS BUSHINGS ON SPOOL

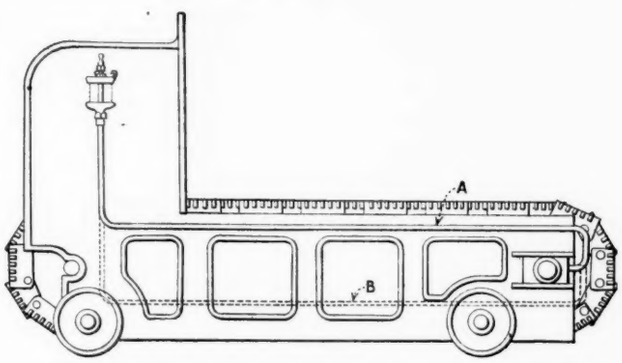
tightly on the piston valve as indicated. These were made large enough so that they could be faced off to the same diameter as the seats in the body.

In order to get the bottom bushing in place, the upper end was made the same size as the lower and was threaded entirely past the guides, so that the lower bushing could be screwed on over the upper end before the upper bushing was in place. The upper bushing was made as wide as the distance from the top of the valve spool to the bottom of the guide. Then after the bottom bushing was put in place and the top one was put on, they were turned down to fit, and the space between the guides was cut out on the upper bushing, leaving it as it was before, excepting a trifle larger.

Dallas, Texas. H. L. ROBINSON.

A Troublesome Grease Feed Pipe

Recently, we installed a new water-tube boiler and chain-grate stoker. The stoker operated nicely for several months, then developed a squeak in the rear



CHANGE MADE IN LOCATION OF OIL FEED PIPE

sprocket-wheel bearings. The grease feed pipe, shown at *A* in the sketch, was originally equipped with a force-feed grease cup. The fireman complained of not being able to force much grease through the pipe. The cup was removed and the lubricant forced in with a grease gun. This served to stop the squeak for a few days.

Finally, we pulled out the stoker and dismantled the feed pipe. In the region of the point marked *A* in the illustration, the grease was found to be baked solid in the pipe, owing to the pipe being only a few inches below the grate surface.

A new section of pipe was installed, and a sight-feed lubricator replaced the grease cup, using engine oil. This was unsuccessful because the intense heat of the furnace quickly boiled the oil away, and the squeak reappeared.

At last it was decided to lower the pipe and remove it from the region of intense heat as shown by the dotted line at *B*. Lubricating oil is used at the present time and the bearing has given no further trouble.

Louisville, Ky. A. R. KNAPP.

How Not To Produce Compressed Air

It is here proposed to give the details of a remarkable condition of inefficiency found in the air-compressor installation of an engineering firm who, although of good repute for the excellence of design and workmanship in their products, have not yet fully developed the modern methods of efficient production.

Before attempting to set forth particulars of the numerous sources of loss, it might be said that compressed air at one time figured largely in their total

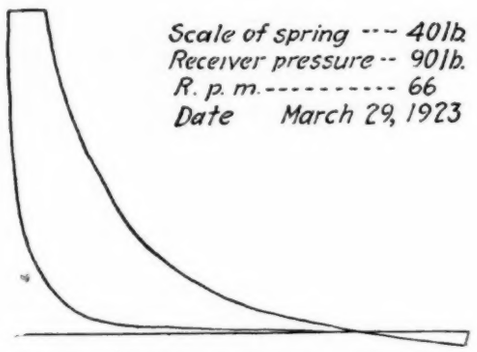


DIAGRAM OBTAINED FROM COMPRESSOR

available power; this power, however, was later reduced through leakages to about half the former output and pneumatic tools could not be operated simultaneously in the various departments. In the boiler shop, which had originally been supplied with numbers of chipping, riveting and calking hammers, not more than a half-dozen tools could be in operation at one time. The air compressor was an old-type horizontal machine and was belt-driven from a machine-tool countershaft. Attention was called to the neglected condition of the plant with the result that permission was obtained to make a report on the whole installation. Incidentally, air leakages were discovered at nearly every joint in the transmission piping; this leakage was found, however, to be incomparable to that at the receiver. Here was found what might be termed a continuous relief valve, the valve blowing the whole time the compressor was in operation. The only reason given for its adoption was that the authority responsible for the operation of the plant objected to the intermittent action of the unloading device supplied with the compressor.

As no particulars for the operation of the plant were available, it was decided to apply to the manufacturers for certain details. When these were received, it was found that the compressor was running at less than half-speed. The investigation was continued and the compressor was indicated, the diagrams obtained revealing the condition of the machines. On the suction stroke a partial vacuum was being created, and the delivery valves allowed high-pressure air to flow back into the cylinder. On examination the suction-valve chambers were found to be choked with oily cotton waste and other matter, and both suction and delivery valves were much worn. An inefficient belt drive transmitted about one-fifth of the estimated required horsepower and at that the slip was continuous. A wood pulley on the countershaft acted as the driver, and the ratio of the pulleys at the available motor speed, gave a very low belt speed. After considering all the details it was finally decided to overhaul the whole installation.

The first thing, in order to permit of an increase in speed, was to lay out a correct foundation. This being done, it was decided to arrange a separate belt drive to the compressor. The power required at the new speed and increased load far exceeded that obtainable from the lineshaft motor, and the cables were already carrying the maximum current. For this purpose an oil engine was recommended, and the belt speed was increased up to the standard for an efficient drive.

The receiver capacity was increased by installing two obsolete Cornish boilers which were suitably strengthened and connected together. Attention was next given to the water-circulating system through the cylinders, etc. The inlet and outflow pipes should have been 1-in. bore, but someone, thinking no doubt to effect an economy, had substituted ½-in. gas piping. This was changed to the larger size. The valves, although worn, were rendered serviceable again by careful grinding in. Many changes were made in the transmission piping. The common mistake had been made in using piping of a ridiculously small size; in this case part of the range was of ½-in. pipe, resulting in large frictional losses coincident with a large pressure drop. A suction filter of easy construction has been designed which, it is hoped, will solve the problem of obtaining clear air-inlet passages and clean air. It is hoped subsequently to give comparative figures showing the remarkable increase obtained in the over-all efficiency and power, from a plant layout which previously must have been deplorably unique.

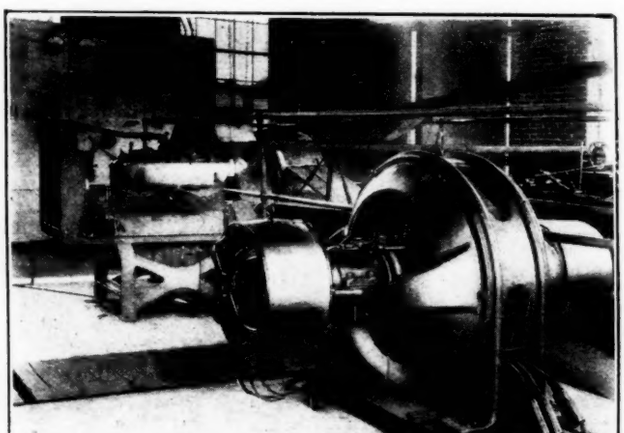
L. GOLDSMITH.

Thetford, Norfolk, England.

Gasoline Engine Prevents Plant Shutdown

The power for the machine shops of an Iowa manufacturer is supplied by a plant containing a Corliss engine and two boilers.

By reason of mine trouble the factory was unable to obtain delivery of coal. In consequence a costly shut-



GASOLINE ENGINE DRIVING GENERATOR

down was threatened. To permit operation, a 60-hp. gasoline industrial engine was placed in line with the generator pulley as shown in the illustration. The engine, as will be observed, is placed on a cast-iron frame suitable for moving from place to place. A radiator eliminates any difficulty with cooling water.

St. Louis, Mo. J. SPUGG.

Comments from Readers

Different Water Levels Shown on Same Boiler

Referring to the inquiry of H. L. in the Sept. 18 issue as to what causes the gages to indicate different water levels on the same boiler, some time ago we had a similar experience and upon investigation discovered the trouble in the automatic valve in the top water-gage cock.

The spring that should have held the valve up had weakened, allowing the valve to close. The water column showed about five inches higher than the correct level. After adjusting the spring we had no further trouble.

Depot Harbor, Ont., Canada. M. F. CHAMBERS.

Causes of No-Voltage Release Coil on Compensator Burning Out

In the Question and Answer department, Aug. 14 issue, it is explained why a no-voltage release coil may have burned out on a compensator for starting an induction motor. I would like to call attention to two things:

First, most of the trouble experienced by me has been due to attendants and repairmen overhauling the release and finding a crack in the iron washers at the coil ends and in various ways closing this opening, from using arc welding to placing metal chips in the slot. This, of course, causes the washers to act as an internal short-circuit in the coil and causes it to burn out.

Second, it is stated in the article that the release coil may be connected across the line all the time that the main switch is closed and that the magnetic circuit of the coil is open, which will cause the coil to burn out. Unless there is some type of compensator that I am not familiar with, the magnetic circuit closes just as soon as the coil is energized, which would prevent the coil burning out under this condition. R. M. BEECHER.

Buffalo, N. Y.

Pounding of Oil Engines Not Caused by Pressure Changes

The article of J. Spugg on oil-engine bearing clearances, which appeared some time ago in *Power*, drew my attention because I do not agree with the statement in the first paragraph about pressure changes in steam and oil engines respectively. He states that the pressure change in oil engines is more rapid that in steam engines. In my opinion the reverse is true.

The high compression of the oil engine has a cushioning effect, and after injection takes place the pressure remains constant during the first part of the stroke. Further, the admission line of the steam-engine diagram generally is steeper than the explosion line of an Otto engine. The terminal pressure in any type of internal-combustion engine is higher as in the case of the steam engine. Consequently, pounding of oil engines is not caused by excessive pressure changes, but by lost motion in the reciprocating parts. Vertical engines, as a rule, run silent only during a short period inasmuch as the pistons always have a tendency to swing around the piston pins, thereby producing a characteristic noise. In my opinion this is the most prolific cause of pounding. H. WIELAND LOS.

Schoonhoven, Holland.

Poppet Valves on American Engines

I have read with interest W. H. Odell's letter in *Power* in relation to poppet valves.

Among the younger engineers the poppet valve as an old thing seems to be unrecognized, and one engine builder states in his circular that it was first used by Sulzer, of Switzerland, in 1865. I remember seeing these valves used on the steamer "Young America," which ran on Narragansett Bay before 1860. John Bourne, in a treatise on the steam engine published in 1866, but having a preface dated 1861, speaks of "spindle valves" and "equilibrium valves," saying of them, "This species of valve is very much used in America on engines of various kinds and is used on Cornish pumping engines."

J. & S. W. Putnam Co., now incorporated as the Putnam Machine Co., developed their patent poppet-valve automatic regulating stationary engine during the years 1845 to 1850, and in 1856 the Massachusetts Charitable Mechanical Association awarded that company a gold medal for improved steam valves.

S. W. Putnam, Jr., of Fitchburg, writes me that the origin of the poppet valve is shrouded in uncertainty and aside from the possibility of its limited application to marine engines it existed in no other class of engines prior to the advent of the Putnam engine.

From what Bourne says in his book, it would seem probable that the earliest use of the poppet valve was in England and especially in connection with Cornish pumping engines. Anybody who looks into the history of devices will find that they are more likely to have been used in England before he was born than otherwise. F. W. DEAN,

Boston, Mass. Wheelock, Day & Boque, Inc.

Analyzing Indicator Diagrams

In *Power*, Sept. 11, H. Schreck commented on the tangent method of studying indicator diagrams, as described in the issues of May 10 and 24. Some of his remarks are identical with those of Mr. Wolf in the issue of June 5 and have been answered on page 430 of *Power*, Sept. 11. In order to avoid repetition, only a few of his conclusions will be considered.

In Mr. Schreck's opinion the determination of the exponent of expansion cannot be carried on "into the period while fuel is injected—that is, while outside heat is still being contributed"—because "during this period the change of state does not follow the law of an adiabatic curve." This is a mistake. The exponential analysis, no matter what method is used, does not require

that the change should be adiabatic. Outside heat can be contributed during the period. The most valuable result of the analysis is usually the revelation of *when* outside heat is contributed. The only requirement in applying the exponential analysis is that the cylinder content should follow the law of gases, $PV = RT$. And as long as the amount of gas does not change appreciably, and this is the condition during the injection period of an oil engine, this requirement is fulfilled.

Mr. Schreck compares the "Schweitzer method" with the logarithmic method and receives surprisingly divergent results. It should be clear to everybody that both methods, if applied correctly, must give the same results. I have analyzed the same diagram with both methods and found but slight differences. The computations of Mr. Schreck are erroneous in both cases. With the graphical logarithmic method he gets for volume 70, 80 and 90 per cent, $n = 1.428$. Applying the well-known formula,

$$n = \frac{\log. P_1 - \log. P_2}{\log. V_2 - \log. V_1}$$

one obtains with Mr. Schreck's figures for the 70-80 period, $n = 1.43$ and for the 80-90 period $n = 1.28$.

Using the tangent method, he displayed very little skill in drawing tangents and, in computing n he apparently used a wrong scale. In column 4 of his table for expansion, I get with his figures, 1.13, 1.24, 1.36, 1.40, 1.45, 1.15, 1.04, 1.23 instead of his values of 1.02, 1.12, 1.22, 1.26, 1.30, 1.04, 0.925, 1.1.

But I will gladly admit, and Mr. Schreck's discussion fortified him in this opinion, that in using the tangent method for plotting the n curves, if care is taken in drawing the tangents, the errors will be negligible. To test the usefulness of the mirror rule, one may draw tangents to circular arcs, where the tangent is perpendicular to the radius. This is also a good way to acquire practice in using the mirror.

Milwaukee, Wis. P. H. SCHWEITZER, M.E.

Air Compressor Got Red Hot

The article by A. Lacey, "Air Compressor Got Red Hot," in the Aug. 14 issue of *Power* recalls a similar experience I had several years ago while employed in the steam-engineering department of a large steel mill. On this occasion one of the air cylinders and the discharge from this cylinder on a large compound blowing engine that supplied air to a bessemer converter were found to be heating up rapidly. A few minutes after the trouble was first noticed, the discharge pipe was heated up from the cylinder to the converter, a distance of about five hundred feet, and in many places the pipe became red hot.

As soon as the trouble was noticed, the converter was shut down, but the engine was kept turning over slowly. A water hose was turned on the cylinder in order to keep the temperature down. In about twenty minutes the fire apparently burned itself out. Although the cylinder got very hot, a careful examination showed that no apparent damage was done and the engine was soon back in service. During the trouble no pressure developed sufficient to lift the safety valve on the receiver located about one hundred feet from the engine.

Mr. Lacey states that the compressor was shut down immediately at the first sign of heat. I should like to ask if this would have been the best procedure in the case of the blowing engine. Undoubtedly, the fire would have been smothered out owing to the cutting off of the air supply, but might not the intense heat have caused the piston to "freeze" in the cylinder?

No similar trouble had ever been experienced before on this engine or other blowing engines in the plant. However, only a few months before a change had been made from a high-grade oil to a very cheap grade for lubricating the air cylinders of the blowing engines. A further inspection of the discharges of other blowing engines showed them to be covered with a residue composed largely of carbon.

It is my opinion that Mr. Lacey's interpretation of the trouble is correct and that by friction or some other means heat was generated in the cylinder and ignited the carbon. GEORGE E. GASTER.

Tyrone, Pa.

Checking Hydro-Electric Plant Operation

The editorial on "Better Methods of Checking Hydro-Electric Plant Operation" in the Aug. 28 issue, brings to the mind of those charged with the responsibility of securing efficient results from such plants, the numerous ways in which operating economy is lowered by defects or poor operating methods at any number of points between the forebay and the tail water, when insufficient thought and study are given to the various elements comprising the installation. Admitting the value of measuring head and water accurately to check turbine operation, there are yet more important losses present in a good many plants, particularly the smaller ones, which are often neglected. A few instances will suffice to illustrate the point.

In a storage dam supplying two hydro plants in series, it had been the practice for a long time to allow the head to drop down to a point that was considered sufficient to insure a proper entrance head to the penstocks, before starting up the auxiliary steam plant, and then operating as much as possible with the river run-off. Under these conditions the first plant operated with a reduction in head of 30 per cent. A study was made of the situation, taking into consideration the output of the plants on the river run-off during the dry season and also the duration of the latter. The greater output possible with a higher head was balanced against what would be gained by using the water at the lower elevations, and it was found that a greater average output could be obtained by starting the steam plant earlier and keeping the elevation in the dam at a higher level. The most economical level was determined from past operating records and the results amply justify the practice.

A very different type of efficiency promotion occurred in another plant, which has four 750-hp. reaction turbines installed. It is the practice in this plant to close the main turbine gates of all units not in service during the dry season, when most of the load is carried by a steam plant. The four units are equipped with 30-in. single sliding-disk gate valves to which were attached 4-in. bypass valves to equalize the pressure. When the gates were closed, a considerable loss of water took place through them, which was at first thought to be due to worn seal rings in the gate valves. A careful investigation, however, showed that, owing to the age and consequent loss around the guide vanes, the 4-in. bypass valves were no longer sufficient in size to keep up the turbine pressure when the main gates were closing. The result was that the difference in pressure

between the penstock and turbine sides of main gates caused so much friction that it was impossible to close them completely. All four gates were examined and found to lack two inches of being completely closed on the average.

The installation of 6-in. bypass valves permitted complete gate closure, and the saving in this instance was estimated to be over $100 a month in terms of reduced fuel cost at the steam plant because of the greater output possible with a given stream run-off.

A final and no less interesting example was observed in an impulse-wheel plant having two 450-hp. units installed. It appears that after the installation of these wheels it was found that they did not come up to the guarantee and the manufacturer supplied new wheels of slightly larger diameter. When these were in place, it was found that the point of the needle interfered with the wheel when the needle valve was in the closed position. The installer then cut two inches from the point of the needle. This left a blunt point on the needle with a flat face an inch in diameter. The plant ran thus equipped for some time until an investigation brought the matter to light. The blunt needle considerably reduced the efficiency of the jet and thus of the unit, and was corrected by installing a specially made needle nozzle to avoid the necessity of resetting the whole valve support. FREDERICK KRUG,

Supt. of Hydro-Electric Plants,
Porto Rico Railway, Light & Power Co.
Comerio Falls, P. R.

Feeding Boilers with Partly Closed Feed Valves

Referring to the inquiry of Mr. Harris in the Sept. 18 issue, "Does a Partly Closed Feed Valve Increase the Duty on the Feed Pump?" it depends a whole lot on the layout of the plant and the size of the valves. If the boilers are not set so the water lines are all at the same level, it is impossible to keep an even feed on the different boilers without running with the feed valves partly shut and carrying feed-line pressure 5 to 20 lb. above steam pressure. Even where all the equipment is similar, it is difficult to get all the feed valves set so the boilers will feed evenly and especially so if the load varies considerably. One of the most satisfactory methods of hand feeding is to have a differential pump governor set for about 5 lb. above steam pressure, so that within reasonable limits the feed valves can be adjusted without constantly changing the pump throttle.

I do not think that there will be any noticeably increased strain and pounding in the feed line when feeding with the feed valves partly closed than when running with them wide open except when too many of the partly closed valves are opened wider without regulating the pump throttle, as in this case the pump will race more or less and the line may pound badly. In our own plant I have found more trouble from pounding due to internal feed pipes coming loose and checks breaking than from running with valves partly closed. This is a necessity, as we have two boilers with the water line nearly ten feet above the other four, but the water tender watches the feed-line pressure and it gives no trouble even when the regulator is laid up for repairs.

In the ordinary duplex feed pump the friction of the pump and cylinder condensation are so great that the increased steam to do 10 to 15 per cent more useful work would probably not amount to more than 3 to 5 per cent of the total steam consumption, and this side of operating with partly closed feed-valves is not important. H. D. FISHER.

New Haven, Conn.

The last paragraph of Mr. Harris' letter in the Sept. 18 issue reads as follows:

> The difference in the working of the pumps under these two conditions may not be noticed in an up-to-date plant where feed lines are properly installed with long-radius bends, gate valves, etc., but in a small plant usually very little attention is paid to what extent the feed valves are open, or to the duty on the feed pump, as long as the boiler gets sufficient water.

I should judge from this that he has reference to globe valves? If so, I should like to call his attention to an item in the Aug. 28 issue, page 326 of *Power*, which reads as follows: "Globe valves offer 15 to 40 times as much resistance to water as gate valves of the same size. The ratio increases as the sizes of the valves are increased." I will also refer him to an article in the issue of Aug. 14, page 244: "The loss of head in a 1½-in. gate valve at a velocity of 6 ft. per sec., for water, is 11 ft. when one-quarter open, 3.8 ft. when three-eighths open and 1.6 ft. when one-half open. When three-quarters and full open, the loss is less than one foot of water."

He can see from the foregoing that there is a *loss*, no matter what type of valve is used, also that the loss varies at different openings of the valve.

I suggest that he attach a pressure gage close to the pump on the feed line that runs to the boilers, then run his pump at different speeds and close his valve so as to have different openings. He will then be able to test this out, and obtain the information he desires.

Norwich, Mich. THOMAS J. PASCOE.

The inquiry of Mr. Harris recalls my experience while in charge of a marine plant where a pump and two injectors were used for boiler feeding. The pressure carried on the boiler was 175 lb. gage. A coil heater constructed with numerous return bends, elbows, etc., was located in the top of the boiler. Owing to the additional friction head put on the pump by this heater and piping arrangement, it was necessary to repack the pump every two weeks, and the injectors would not work satisfactorily unless we bypassed the heater. Finally, the heater was cut out of service. Then we packed the pump once every season and the injectors worked all right.

I recite this case by way of illustrating that every bend and turn, every valve and check has a certain frictional resistance. I would advise running the pump "on the throttle" or installing a pump governor and leaving all discharge valves open. R. G. SUMMERS.

Rochester, N. Y.

Bleeding the main unit of a power house for heating feed water is preferred to using the exhaust of steam auxiliaries. This is for the reason that large units are sometimes twice as efficient as small auxiliaries. With these relative efficiencies, it is reasonable to expect that, for a given amount of exhaust-heat required, the power available from the use of steam that has passed through the early stages of a large turbine will be much greater than that from the exhaust of non-condensing auxiliaries. Steam exhausted from auxiliaries will have a higher superheat than that bled from large units. This is because more heat is extracted by the large unit.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Meaning of Acre-Foot

What is meant by the term "acre-foot" as applied to the capacity of a reservoir? T. F.

The term "acre-foot" formerly was used as a unit for measuring irrigation; it means a body of water 1 acre in area and 1 ft. in depth. It is therefore a true unit of volume and as such is frequently used with reference to rate of stream flow and also with reference to reservoir capacity. The chief equivalents of acre-foot are: 325,851 gallons; 43,560 cubic feet; 1,613.33 cubic yards and 1,233.49 cubic meters.

Usual Sizes of Feed Connection for Fire-Tube Boilers

What sizes of feed connections are used for ordinary sizes of vertical fire-tube and horizontal return-tubular boilers? R. C.

Vertical boilers containing less than 225 square feet of heating surface usually are supplied with ¾-in. feed-pipe connections; 225 to 600 sq.ft., ¾-in.; 600 to 800 sq.ft., 1-in.; and 800 to 1,300, 1¼-in.

Horizontal return-tubular boilers up to 48 in. in diameter and 700 sq.ft. of heating surface usually are supplied with 1-in. feed connections; 54-in. boilers (approximately 700 to 850 sq.ft. of heating surface) 1¼-in.; 60-in. boilers (approximately 880 to 1,150 sq.ft. of heating surface) 1½-in.; 66-in. boilers (approximately 1,300 to 1,550 sq.ft. of heating surface) 1½-in.; 72-in. boilers (approximately 1,600 to 1,850 sq.ft. of heating surface) 1½-in.; 78-in. boilers (approximately 2,000 to 2,200 sq.ft. of heating surface) 2-in.; 84-in. boilers (approximately 2,200 to 2,700 sq.ft. of heating surface) 2-in.

Sizes of Butt- and Lap-welded Pipe

Why are the actual sizes of pipe smaller than 1 in. inside diameter made to vary so much from the nominal sizes? I can tell nominal ⅜-in. or ¼-in. pipe on sight, but do not understand why the pipes are not made with actual inside diameters to conform more nearly to their designations, as in the case of 1-in. pipe. M. G. C.

The nominal sizes of iron pipe 10-in. and under were established by the British "tube" or pipe trade between 1820 and 1840, according to sizes then manufactured and most commonly used. The original designations of nominal inside diameters were applied to the nearest corresponding outside diameter suitable for standard diameters of screw threads. The outside diameters have been slightly modified to conform to the modern standard system of pipe threads, but there have been considerable variations in the actual inside diameters of different nominal sizes of wrought iron and steel pipe from changes in the thickness given to pipe walls, to suit required proof pressures, materials of fabrication and processes of manufacture, as it would be impractical to adapt the changes to fixed even sizes of inside diameters with variations in outside diameters required for screw threads.

Testing Slip of Pump

How can the slip of a steam pump be tested? S. W.

Slip of a pump generally is stated as loss in percentage of displacement and is dependent upon the condition of the pump, the pressure and the speed.

For a given pressure the leakage may be regarded as constant, and consequently this percentage will increase with decreasing displacement. Hence, to approximately determine the slip, close the discharge valve and admit sufficient steam pressure to produce the normal water pressure. The speed then obtained, multiplied by 100 and divided by the normal speed, will be the slip or percentage of leakage for the normal speed and discharge pressure at which the pump is operated.

Water Hammer in Long Boiler-Feed Line

What is the best method of preventing water hammer in a long feed-water line to a battery of boilers? E. J. S.

Provide an air chamber at each end of the line, having each air chamber volume about ten times the volume of the pump piston displacement per stroke. If the air chamber can be placed where there are elbows in the line, replace the elbows by tees so arranged that the discharge from the pump and the inlets to the air chambers are connected on the runs of the tees. Air chambers are worthless for absorbing shocks if they become filled with water, and to insure good service each air chamber should be provided with a glass gage for determining at sight whether they need draining and refilling with air, and suitable connections and fittings should be provided for that purpose.

Shutting Down Refrigerating Plant

When shutting down an ammonia compressor, what is the proper method of shutting the valves and stopping the compressor? F. J.

Close the expansion valve and run the compressor until the pressure is about zero. The suction valve should now be closed and the compressor cylinder exhausted of ammonia gas by pumping it a little while and until the gage on the suction elbow shows about zero gage pressure. The compressor discharge valve is then closed and the water is allowed to run for a considerable length of time on the condensers, until the

ammonia vapor is condensed as far as possible and the pressure-gage reading on the condenser drops to a point where it remains stationary. The water then should be cut off and the various valves on the condenser closed. However, if the receiver is placed inside of the engine room, under no consideration should the valve between the receiver and the condenser be closed, for if the receiver is filled with liquid, the heat that the ammonia will pick up from the room will cause it to expand and break the receiver. The proper procedure is to close the intake valve to the condenser and leave the outlet valve open.

Cylinders of Direct-Acting Steam Pumps

What determines the selection of relative diameters of steam and water cylinders of direct-acting steam pumps used for boiler feeding? W. L. C.

Direct steam boiler-feed pumps are ordinarily intended to be operated with steam obtained from the boilers which they serve with feed water, and in addition to overcoming the boiler pressure, the steam ends must be of sufficient size to operate with a suction lift when required, overcome friction and other resistances of working parts of the pumps and work against the pressure required for overcoming the frictional resistance of the water in pump passages, valves, pipes and fittings with the maximum rate of discharge. All these conditions usually are met by having steam pistons of about twice the area—that is, about 1.4 times the diameter—of the water cylinders.

Point of Cutoff Running Non-Condensing or Condensing

A 24x48-in. engine running 60 r.p.m., operating non-condensing, develops 400 i.hp. with initial steam at 100 lb. gage. What is the point of cutoff and what would be the point of cutting off when developing the same power operating condensing with 27 in. vacuum? H. W. P.

Assume that *A B C D E* in the illustration represents the indicator diagram made when the engine operates non-condensing, and *A K L R S*, drawn in broken lines, represents the diagram that would be obtained with the same load when operating condensing. Development of the same power in each case would require the same m.e.p., namely,

$$\frac{400 \times 33{,}000}{\textit{piston area} \times \textit{feet of piston speed per min.}}$$

The piston area $= 24 \times 24 \times 0.7854 = 452.39$ sq.in., and the piston speed $= \frac{48}{12} \times 2 \times 60 = 480$ ft. per min., hence

$$m.e.p. = \frac{400 \times 33{,}000}{452.39 \times 480} = 60.8$$

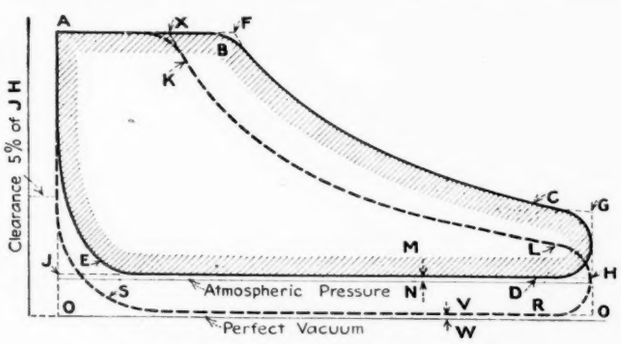
When operating non-condensing with the diagram *A B C D E*, from drop of the admission pressure during admission *A* to *B*, rounding of the diagram at cutoff as at *B*, release at *C* and compression as at *E*, the actual diagram obtained is about 94 per cent of the theoretical diagram *A F G H J* exhausing against the same back pressure, and the m.e.p. of the theoretical diagram would be $60.8 \div 0.94 = 64.67$ lb.; with back pressure 2 lb. gage, or 17 lb. absolute, the average forward pressure would be $64.67 + 17 = 81.67$ lb. per sq.in. absolute, and for the initial pressure of 100 lb. gage, or 115 lb. per sq.in. absolute, the average pressure per pound of initial absolute pressure would be $81.67 \div 115 = 0.71$ lb.

If *A K L R S* is the actual diagram when operating condensing with 27 in. vacuum and 30 in. barometer, the back pressure *VW* above perfect vacuum *OO* would be $(30 - 27) \times 0.491 = 1.47$ lb. per sq.in. absolute; and to realize 64.67 lb. m.e.p. the average forward pressure would have to be $64.67 + 1.47 = 66.14$ lb.; and with the initial pressure of 115 lb. absolute the average pressure per pound of initial absolute pressure would have to be $66.14 \div 115 = 0.575$ lb.

It may be assumed that the cylinder clearance is 5 per cent. When the average pressure $= P$, actual ratio of expansion $= R$, fraction of stroke at which cutoff occurs $= f$, and percentage of cylinder clearance $= c$, then

$$P = (1 + \log_e R)\ (f + c) + c$$

A table of "Mean Pressures per Pound of Initial, with Different Clearances and Points of Cutoff," computed



DIAGRAMS OBTAINED WHEN OPERATING NON-CONDENSING AND CONDENSING

from the foregoing formula, is given on page 115 of Low's "Steam Engine Indicator," and from inspection of this table it may be seen that the mean pressure 0.71 lb. per pound of initial absolute to be obtained when operating non-condensing would correspond to cutoff *F* at about 0.33 of the stroke; and for the mean pressure 0.575 lb. per pound of initial absolute required when operating condensing to develop the same power, the point of cutoff *X* would correspond to cutoff at about 0.21 of the stroke.

Hydrostatic Test Pressure for Boiler

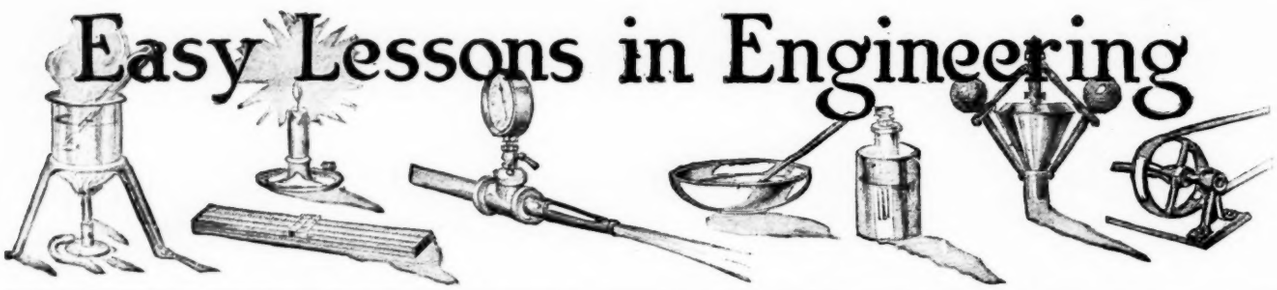
What should be the hydrostatic test pressure for a boiler that is operated at 200 lb. gage with the safety valve set to blow at 205 lb. gage? W. D.

The pressure at which the safety valve is set to blow must be considered to be a pressure that is likely to be attained, regardless of whether it is intended to operate the boiler at less pressure. Hence, if the safety valve is set to blow at 205 lb. gage, that pressure must be presumed to be the maximum allowable working pressure, determined from competent inspection of the design, construction and condition of the boiler and consideration of its age and proposed method of operation.

As a boiler should be subjected to one and one-half times the maximum allowable working pressure, the hydrostatic test pressure should be $205 \times 1\frac{1}{2} = 307.5$ lb. gage.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Easy Lessons in Engineering



Heat Balance of a Boiler

Articles in previous issues[1] explained how to figure boiler efficiency, how to compute the various boiler losses and how to prepare the simplest kind of a heat balance for an elementary plant. The present article will show how to make a fairly complete heat balance of a boiler.

Assume that a boiler has been tested and the following data obtained:

Weight of coal fired per hour, lb.	1,096
Weight of water evaporated per hour, lb.	7,310
Heat value of fuel as fired, B.t.u. per lb.	13,800
Proximate analysis of fuel as fired:	
Moisture, per cent	3.1
Volatile, per cent	17.6
Fixed carbon, per cent	69.4
Ash, per cent	9.9
Steam pressure, lb. gage	148
Superheat, deg. F.	114
Feed-water temperature, deg. F.	204
Weight of ashpit refuse per hour, lb.	186
Room temperature, deg. F.	75
Stack temperature, deg. F.	545
Flue-gas analysis:	
CO_2, per cent	7.2
CO, per cent	0.5

The heat balance must show, as far as practicable, just where all the heat in the coal goes. The amount dealt with may be either the total coal fired per hour or a single pound. The latter gives smaller figures and is generally more convenient. In addition the distribution of the heat in the coal may be expressed on a percentage basis. In this case we will use both the pound-of-coal basis and the percentage basis.

Starting with one pound of coal containing 13,800 B.t.u., we must consider first how much is actually used in making steam. The amount of water evaporated per pound of coal fired is 7,310 ÷ 1,096 = 6.66 lb. So the heat put into the steam per pound of coal fired will be the product of 6.66 by the heat required to turn one pound of feed water at 204 deg. into steam at 148 lb. gage and 114 deg. superheat. The heat in one pound of steam at 163 lb. absolute and 114 deg. superheat is 1,259 B.t.u., while that in water at 204 deg. is 204 — 32 = 172 B.t.u. To make steam, therefore, requires 1,259 — 172 = 1,087 B.t.u. per lb., or 1,087 × 6.66 = 7,239 B.t.u. for 66.6 lb.

This accounts for 52.5 per cent of the heat in the coal. The rest must be lost in various ways. Take first the ashpit loss. The ashpit refuse per pound of coal is 186 ÷ 1,096 = 0.170 lb. The coal analysis shows that one pound of coal contains only 0.099 lb. of ash along with 0.870 lb. of combustible material and 0.031 lb. of moisture. Therefore the refuse from one pound of coal must contain 0.170 — 0.099 = 0.071 lb. of combustible. The heating value of the combustible is 13,800 ÷ 0.87 = 15,862 B.t.u. per lb., so this loss is 15,862 × 0.071 = 1,126 B.t.u., or 8.2 per cent of the heat in the coal fired.

Next comes the big loss in the flue gas due to throwing away a large weight of gas at high temperature. To figure this exactly is a long and complicated process, so the approximate method developed in the Sept. 25 and Oct. 2 issues will be used. It was there shown that for an average bituminous coal the flue loss in per cent $= 0.02 \times \frac{21}{1.15 \times \text{per cent } CO_2} \times$ temperature difference. This reduces to 0.36 × temperature difference ÷ per cent CO_2. Where CO is present, one-half the percentage of CO should be added to the CO_2. We then have:

Percent loss in hot gases = 0.36 × (545 — 75) ÷ (7.2 + 0.25) = 0.36 × 470 ÷ 7.45 = 23 per cent. In B.t.u. this loss is 13,800 × 0.23 = 3,174 B.t.u.

To figure the loss due to CO, note that the flue gas contains 7.2 per cent CO_2 and 0.5 per cent CO. So, of the total CO_2 and CO, the fraction $\frac{0.5}{7.2 + 0.5} = 0.065$ is CO, meaning that 6.5 per cent of the carbon burns to CO. Since we do not know the total carbon in the coal or what part of the hydrogen is unburned, great refinement here is useless and we may as well assume that 6.5 per cent of the total heat in the coal is lost in incomplete combustion. This is 897 B.t.u.

While we know that the original coal contains 3.1 per cent of moisture, this will not enable us to figure the loss due to the evaporation of moisture, because the 3.1 per cent is small compared with that formed by burning the hydrogen in the coal. It is necessary, in the absence of an ultimate analysis, to assume the total hydrogen content of the coal (including that in the original moisture). Take it at 5 per cent (a good average figure for bituminous coal). Then the 0.05 lb. of hydrogen in a pound of coal would produce 0.05 × 9 = 0.45 lb. of water. To heat this up, evaporate it at atmospheric pressure and superheat to flue temperature takes about 1,250 B.t.u. per lb., or a total of 1,250 × 0.45 = 562 B.t.u., or 4.1 per cent of the heat in the coal.

The figures are now at hand for the heat balance and need only be assembled as shown in the accompanying table. Note that the item "Radiation, leakage and unaccounted for" is "doped" to make the columns add up correctly. In other words, this item merely lumps all the losses that were not figured as well as the errors.

HEAT BALANCE OF BOILER

	B.t.u.	Per Cent
Heat absorbed by boiler	7,239	52.5
Lost to the ashpit	1,126	8.2
Loss in hot flue gases	3,174	23.0
Loss due to incomplete combustion	897	6.5
Loss due to moisture	562	4.1
Radiation, leakage and unaccounted for	802	5.7
Heat in coal	13,800	100.0

[1] See "How to Test a Boiler," Aug. 14; "The ABC of Heat Balance," Sept. 18; "The Meaning of CO_2," Sept. 25; "Losses Up the Stack," Oct. 2; "Grate, Radiation and Leakage Losses in Boilers," Oct. 9.

The Electrical Structure of Matter*

FROM *Power's* SPECIAL CORRESPONDENT

The Ninety-first Annual Meeting of the British Association for the Advancement of Science was opened at Liverpool on Wednesday, Sept. 12. The president this year is Sir Ernest Rutherford, now professor of physics at the Cavendish Laboratories of Cambridge University and noted as one of the most active research workers in the branch of science dealing with radio-activity. The presidential address upon "The Electrical Structure of Matter" was therefore anticipated with great interest, and the Philharmonic Hall, in which the inaugural meeting was held, was filled to its utmost capacity.

The address dealt with the discoveries and advances in the realm of physical science since the year 1895, when Roentgen discovered X rays and thus gave a great stimulus to the investigation of the fundamental structure of matter. Although Sir Ernest Rutherford's address contained no epoch-making pronouncement upon the structure of the atom, it provided a useful and stimulating résumé of all the recent discoveries and researches on this subject.

Discussing the views held by chemists and physicists thirty years ago, the president stated that no fixed ideas were held at that time as to the structure of the atom, but there was a general belief that the periodic variations of the properties of the elements, brought out clearly by Mendeleef, could be explained only if atoms were similar structures constructed of similar material. The name "electron" had even so long ago as 1896 been given to this fundamental unit by Johnston Stoney, and its magnitude had been roughly estimated.

INDEPENDENT EXISTENCE OF THE ELECTRON RECOGNIZED

The full recognition of the significance of this conception of the atom belongs, however, to the new epoch. The proof in 1897, of the independent existence of the "electron" as a mobile electrified unit of very minute mass when compared with that of the lightest atom, was of great importance and assisted to clarify these vague ideas. It was soon recognized that the electron must be a constituent of all the atoms of matter and that optical spectra must have their origin in electronic vibrations.

In the early development of this subject science owes much to the work of Sir J. J. Thomson, both for the boldness of his ideas and for his ingenuity in developing methods for the estimation of the number of electrons in the atom and of probing its structure. In the meantime our whole conception of the atom and of the magnitude of the forces which held it together was revolutionized by the study of radio-activity. The discovery of radium was a great step in advance, for it provided the experimenter with powerful sources of radiation, especially suitable for examining the nature of the characteristic radiations which are emitted by the radio-active bodies in general. It was soon shown that the atoms of radioactive matter were undergoing spontaneous transformation, and that the characteristic radiations emitted, namely, the α, β and γ rays, were an accompaniment and consequence of these atomic explosions. The wonderful succession of changes that occur in uranium, more than thirty in number, was soon disclosed and interpreted on the transformation theory. The radioactive elements provided us for the first time with a glimpse into nature's laboratory, and allowed us to watch and study, but not control, the changes that have their origin in the heart of the radioactive atoms. These atomic explosions involve energies which are gigantic compared with those involved in any ordinary physical or chemical process. In the majority of cases an α particle is expelled at high speed, but in others a swift electron is ejected, often accompanied by a γ ray which is a very penetrating X ray of high frequency. The proof that the α particle is a charged helium atom, for the first time disclosed the importance of helium as one of the units in the structure of the radioactive atoms and probably also in that of the atoms of most of the ordinary elements. Not only then have the radioactive elements had the greatest direct influence on natural philosophy, but in subsidiary ways they have provided us with experimental methods of almost equal importance. The use of α particles as projectiles, with which to explore the interior of the atom, has definitely exhibited its nuclear structure, has led to artificial disintegration of certain light atoms, and promises to yield more information yet as to the actual structure of the nucleus itself.

FURTHER STUDY FELL NATURALLY INTO TWO DIVISIONS

When once the salient features of the structure of atoms had been fixed, and the number of electrons known, the further study of the structure of the atom fell naturally into two divisions—one, the arrangement of the outer electrons which control the main physical and chemical properties of an element; and the other, the structure of the nucleus, upon which the mass and radioactivity of the atom depend.

Without going into detail, a few examples may be given to illustrate the conclusions that have beeen arrived at. Hydrogen is believed to have a nuclear charge of 1, and one electron; helium has a nuclear charge of 2, and two electrons, moving in coupled orbits. These two electrons form a definite group, known as the K group, which is common to all the elements except hydrogen. For increasing nuclear charges, the K group of electrons retain their characteristics, but move with increased speed and approach closer to the nucleus.

As we pass from helium, with the atomic value of 2, to neon, with a value of 10, a new group of electrons is added, consisting of two sub-groups each of four electrons. This group is known as the L group and appears in all atoms of high atomic value. As in the case of the K group the speed of motion increases and the size of their orbits decreases with the atomic value. When once the L group has been completed, a new and still more complicated M group of electrons begins forming outside, and a similar process goes on until uranium, which has the highest atomic value, is reached.

It may be of interest now to try to visualize the conception of the atom, by taking the heaviest one, uranium, as an illustration. At the center of the atom is a minute nucleus surrounded by a swirling group of 92 electrons, all in motion in definite orbits and occupying, but by no means filling, a volume very large when compared with that of the nucleus. Some of the electrons describe nearly circular orbits round the nucleus, while others describe orbits of a more elliptical shape. The motion of the electrons in the different groups is not necessarily confined to a definite region of the atom, for the electrons of one group may penerate deeply into the region mainly occupied by another group, thus giving a type of interconnection or coupling between the various groups.

SPEED OF ELECTRONS

The maximum speed of any electron depends on the closeness of its approach to the nucleus; but the outermost electron will have a minimum speed of 1,000 kilometers (3,280,830 ft.) per sec., while the innermost K electrons have an average speed of more than 150,000 kilometers per second, or half the speed of light.

In reaching these conclusions, which we owe very largely to Professor Bohr and his co-workers, every available kind of data concerning the different atoms has been taken into consideration.

We have not so far referred to the very difficult question of the explanation on this theory, of the chemical combination of atoms. In fact, as yet the theory has hardly concerned itself with molecular structure. On the chemical side, however, certain advances have already been made, notably by G. N. Lewis, Kossel, and the American physicist Langmuir, in the interpretation of the chemical evidence by the idea of shared electrons, which play a part in the

*From an address by Sir Ernest Rutherford at the British Association for the Advancement of Science at Liverpool, England.

electronic structure of two combined atoms. There can be little doubt that the next decade will see an intensified attack by physicists and chemists on this very important but undoubtedly very complicated question.

Since it was believed that the radioactive elements were analogous in structure to the ordinary inactive elements, the idea naturally arose that the atoms of all the elements contained a similar concentration of energy, which would be available for use if only some simple method could be discovered of promoting and controlling their disintegration. This possibility of obtaining new and cheap sources of energy for practical purposes was naturally an alluring prospect to the lay and scientific man alike. Unfortunately, although many experiments have been tried, there is no evidence that the rate of disintegration of these elements can be altered in the slightest degree by the most powerful laboratory agencies. With increase in our knowledge of atomic structure there has been a gradual change of our point of view on this important question, and there is by no means the same certainty today as a decade ago that the atoms of an element contain hidden stores of energy.

Automatic Engine-Stop Specifications Approved

On Sept. 24, 1923, at the Monday afternoon session of the Association of Iron and Steel Electrical Engineers' 17th annual convention, held in Buffalo, N. Y., Walter Greenwood, chairman of the Association's Safety Committee, presented "General Specification for Construction and Installation of Automatic Engine Stops." At this meeting these specifications were approved, and are given complete in the following:

These specifications shall be known as the "Association of Iron and Steel Electrical Engineers' Specifications." It is intended they will apply to all automatic engine stops of whatever kind or method, in so far as they or any part of them may be applicable.

Automatic Quick-Closing Valves

For steam pressure above 150 lb. extra-heavy valves should be used. Preferably they should be of steel on account of shock, high pressure and high temperature.

A combination stop and throttle should not be employed where the steam line is above 3½ in. in diameter.

For condensing steam engines and for turbines, vacuum breakers should be used and operated in conjunction with the stop valve.

Valves should be of full working capacity to insure minimum pressure loss, at the same time should not be so large that leakage past clearances will operate engine without load at full speed.

Drawings showing full directions for installing and wiring should be furnished by the manufacturer.

So far as possible the use of fibrous packing or packing composed wholly or in part of organic matter should be avoided. Metallic packing should be used wherever practicable.

Stems that must be packed to prevent leakage of steam preferably should extend in or above a horizontal line.

Where an automatic valve is constructed with a bypass for equalizing pressure on both sides in order to reset it, the valve in the bypass should be of such make that it cannot remain in the position that would prevent the main valve from operating after the attendant had released his hold on the bypass valve.

Electrical Equipment

Current—Where high-tension direct-current 110 to 220 volts is available, current should be supplied by generators in addition to current furnished by storage batteries. The batteries should be of sufficient capacity to deliver necessary current during the interruption of main source of supply for any period that is likely to occur. The number of cells should be so proportioned to the resistance that they will float on the line when fully charged. Battery should be placed in a clean, cool place easy of access. Preferably, one battery of sufficient capacity for all engine stops in a plant should be provided.

Switches—Switches and contacts for opening the circuit should break on both sides of the line, in order to prevent the current from being maintained through a ground on one line. Where engines or turbines are connected to generators, a holding or knock-out coil on the circuit breaker should be placed in series with the stop circuit, or a separate circuit should be provided to trip the breaker when the automatic stop operates.

Stop Stations—Switches at stop stations must be of the type for manual operation. They should be inclosed in dustproof cases having glass in the covers that can be broken to operate the switch. The cover should be supplied with a lock so that the case cannot be opened unless for the purpose of renewing glass or for making tests without breaking the glass.

Switchboards—The panels should be slate and not less than one inch thick, or of other insulating material. Mounted on the switchboard, for closed-circuit system, should be a voltmeter, ammeter, charging instrument, adjustable resistance and dial switch so arranged that the charging rate of battery may be varied at will; a main switch and as many circuit switches as may be required; an automatic reverse-current circuit breaker so arranged that, in event the voltage drops or fails entirely, it will automatically disconnect the battery from the generator and will, as soon as the voltage is restored, again connect the battery and generator.

Wiring—The wiring should be double throughout, extending to the tripping apparatus and vacuum breaker, if there is one. In case wires are extended for more closers, the wires should be opened, extended to the new closers and back in the line again that all circuit breakers or closers may be included. Wires should never be shunted to other wires.

Test Board—For an open-circuit system a test board should be supplied, containing the necessary equipment for making tests. The wires should be so arranged that tests can be made to prove that all are intact, including wiring to the coil itself, without tripping the stop. The switch for this purpose must be held normally in position by spring tension, so that it is impossible to leave it in the testing position.

Tripping Devices

Governors—Where a flyball governor with belt drive is used for the initial requirement in bringing an automatic stop in operation, it may be of the horizontal or of the vertical type; that is, the spindle may be horizontal or vertical.

Belting—The governor should be driven by multiple rope drive to insure positive operation even though all but one of the ropes should fail. Each rope should be amply strong to perform the work required of all.

Pulleys—The pulleys should be grooved and should be proportioned for normal speed. If a flat belt is used, the pulleys should be flanged on both sides. Where more than one flat belt is used, they should travel on separate pulleys.

Adjustment—The governor should be so adjusted that it will, by performing some office, like breaking or closing a circuit, tripping a latch, etc., bring some auxiliary part into operation, which in turn will cause the automatic valve to close when the engine reaches the maximum limit of speed required for tripping, which should be approximately 10 per cent in excess of normal.

Horizontal Governor—A governor of the horizontal type should have an idle arm and pulley attachment, with the pulley riding on the belt so that should all the belts break or come off, the arm will swing down and open or close the circuit, as the case may require, through the medium of suitable attachments.

Vertical Governors—A governor of the vertical type should be provided with an idle arm and pulley attachment with the pulley riding on the belt as described for horizontal governors, or it may be so constructed the belt will, by its tension, hold the pulley shaft of the driven pulley on a line that is at right angles with the line of travel of the belt, and so that if the belt breaks or comes off, the vertical spindle will revolve sufficiently to make or break the electric circuit, through the medium of suitable attachments, as may be required by the system employed.

Motion Rectifiers—If a governor is used for bringing the stop into action or a reversing engine, a motion rectifier should be provided for converting alternating rotary motion, as produced by reversing blooming-mill engines, into motion of one direction, to prevent its going into action due to sudden reversal at or below normal speed.

Steam-Operated Governors—The same general arrangement prescribed for breaking electric circuits or tripping

mechanical devices should be followed, so far as belt drive is concerned, in the installation of steam-operated governors. Valve stations for bringing the emergency valve into operation should be located at not more than 30 ft. distant from the stop valve.

Pins Projected by Centrifugal Force—Where a pin, that is projected by centrifugal force for operating a tripping device, is pocketed in the rim of a flywheel, a crankpin disk or a counterbalancing sector, or a yoke on an engine shaft—the yoke being specially provided for holding a pin—the pin and pocket should be machined for an easy fit, but not too loose. If a compression spring is used, the spring should be of such diameter that it will not bind in the pocket when reduced in length by its utmost compression, and the coils should be so open that the utmost compression required will not bring them in contact with each other.

Is All Corrosion Electrochemical?

Few subjects are of more practical importance or involve larger sums of money than that of corrosion. At the same time the problem of corrosion is highly complicated and seems to be leading the chemists a merry chase. One of the few facts well established is that under ordinary commercial conditions the amount of dissolved oxygen limits the corrosion of metal by water.

After making a careful experimental and theoretical study of corrosion, Ulick R. Evans presented a comprehensive paper on the subject before a meeting of the British Institute of Metals, held Sept. 10 to 13 at the Manchester College of Technology. The following paragraphs cover some of more important conclusions reached by Mr. Evans:

While it is often claimed that there is such a thing as "pure chemical" corrosion, it remains to be demonstrated, at least at normal temperatures, that there is any form of corrosion that is not fundamentally electrochemical. It is superfluous to invent "pure chemical" explanations of corrosion, when the well-known principles of electrochemical action lead to conclusions that correspond closely with the experimental facts.

Consider the case of a metal immersed in a liquid. If the metal is absolutely uniform, both chemically and physically, the potentials between the metal and the liquid will be the same at all points and no current will be set up. No electrochemical corrosion is, therefore, to be expected. It is significant here to recall that, in the case of iron and lead, Lambert and his co-workers have actually succeeded in preparing materials so pure and uniform that they do not corrode under conditions that allow rapid attack of materials of merely ordinary purity.

If, on the other hand, the metal is not uniform, varying from place to place either in chemical or physical character, it is certain that at the moment of immersion there cannot be equilibrium. The potentials will vary from point to point, and a current (momentarily at least) must be set up between the different areas. These areas may be divided into anodic areas (anodes) where the current passes from the metal to the solution, and the cathodic areas (cathodes) where the current passes from the solution back into the metal. At the anodic areas the metal will begin to pass into the ionic condition, while at the cathodic areas hydrogen gas will start to accumulate. This accumulation of hydrogen, however, will at once begin to alter the potential of the cathodes, making it more nearly equal to the potential at the anodes. If this process of hydrogen accumulation continues till the potentials at the original anodes and cathodes become equal, equilibrium will be established. In such a case there can be no appreciable electrochemical corrosion.

Two occurrences, however, may prevent the establishment of equilibrium. One is that before the potentials become equal, so much hydrogen may accumulate at the cathodes that it begins to stream out in bubbles. In this case corrosion will continue indefinitely at the anodes.

If, however, the conditions are such as not to allow the evolution of gaseous hydrogen in bubbles, a relatively slow removal of hydrogen from the cathodes may take place if oxygen (or an oxidizing agent) is present in the solution.

The latter type of corrosion is probably the more important industrially. This type occurs when metals like iron nickel, cadmium and lead, that do not displace hydrogen in bubble form when placed in a neutral solution, nevertheless are corroded slowly by such a solution (say, of common salt) if it contains dissolved oxygen. Likewise copper, which cannot cause the evolution of hydrogen gas from dilute acids, dissolves slowly in these acids in the presence of oxygen. This type of corrosion will always be comparatively slow, the rate being limited by the rate of diffusion of oxygen across the layer next to the metallic surface. Consequently, within certain limits, the rate of corrosion will be nearly independent of the electrical conductivity of the solution. There is no reason why oxygen should diffuse more quickly through a highly conducting liquid than through one that conducts badly.

Likewise, within certain limits, the rate of corrosion will be nearly independent of the state of purity or uniformity of the metal. It is true that if we were to obtain absolutely pure and uniform metal, corrosion might be reduced, but with commercially pure metals the rate of diffusion of oxygen is generally the limiting factor. It is true, however, that this rate of diffusion itself depends to a certain extent on the purity of the metal and the nature of the corrosion products, and that to this extent the character of the materials affects the rate of corrosion.

Since the only effect of the dissolved oxygen is to remove the hydrogen from the cathodic areas, the presence of oxygen at the anodes tends (if anything) to reduce corrosion rather than to increase it. In this connection, it is significant that especially marked corrosion often occurs at points to which oxygen can only diffuse very slowly, for instance at the bottom of pits or over areas covered with porous substances, such as string of fabric.

Nickel in Bearing Metals

It has been the practice of some manufacturers to add a small percentage of nickel to white anti-friction or bearing metals. Just what is the effect of this nickel has been a subject of dispute. In a paper by A. H. Mundey and C. C. Bessett, read before the meeting of the Institute of Metals, Manchester, England, the statement is made that originally the nickel was added by one bearing manufacturer merely as a means of identification. The practice was adopted by others until the original reason was lost sight of and engineers came to believe that the addition was of value.

The authors of the paper mentioned conducted a series of tests on such bearings and found that the nickel actually decreased the bearing value of the original mixture. The compression tests showed that the nickel mixture broke down when at fairly low pressures. The elongation was irregular, being characteristic of such nickel alloys, since the alloy is a soft matrix in which very hard constituents are embedded.

The actual running tests were somewhat more favorable, although not so good as tests of white anti-friction metal. It was also noticed that the oil blackened rapidly, evidently from abrasion of the bearing surface.

It appears that the presence of small quantities of nickel have the effect of combining with or dissolving in the copper present, and that the copper-tin compound is broken up; hence the alloy loses that valuable property of resistance to crushing which it appears to owe to the interlocking of the copper-tin compound in its dendritic form, and the hardening effect, if any, of the nickel, does not compensate for the loss of this form of structure.

In conclusion, it would appear that the addition of nickel in such proportions to alloys of this character does not justify itself. No substantial advantages appear to accompany its use, and some valuable properties are diminished—unless it be that certain engineers have established faith in it. If it does give confidence, its use is in a certain measure justified. In the case of high-grade bearings of good design, the stresses are not likely to be so great as to cause failure by an overload, by crushing, although vibration or knocking may have a somewhat similar effect. The actual value of nickel in such bearing metals is, it is thought, still to be proved. It is in general use in Europe but not in the United States.

The Tempering of Coal*

By Thomas A. Marsh†

The subject of tempering of coal deserves some careful consideration and analysis for the reason that in some sections of the country the practice of adding water to coal is quite prevalent and results, as reported from plant operators and as reported on tests, indicate definite advantages for the practice.

On first consideration it would seem that adding a noncombustible to fuel is diametrically opposed to the attainment of higher efficiency or capacity, but observation of operating conditions and results convince that improved results do attend the moistening of certain coals. Among these advantages are: Decreased sifting of coal; fewer holes in fuel bed, hence less excess air; higher combustion rates with given draft; improved quality of ash; better ignition with traveling grate.

These are the items of major importance that have been observed by the author and others on actual evaporative tests. Moreover, in collecting data on this subject the author sent out about 50 questionnaires to combustion engineers and power-plant operators. Practically all using west of Pittsburgh coals reported definite advantage in tempering coal. With Eastern coals the reverse was reported. Few claimed advantages for moistened coal with underfeed stokers. Practically all claimed the advantages mentioned with traveling grates with either natural or forced draft.

It was noted in tests conducted that the air flows more freely through moderately moist coal than through either saturated or dry coal, and that dry coal offered the greatest resistance. No effort was made in these tests to determine the amount of moisture in the samples.

In order to determine more closely this point of minimum resistance to air flow, a 35-lb. sample of sun-dried Illinois coal was taken, using a 6-in. fuel bed, at a constant draft intensity of 0.30 in. This sample was kept in a closed container, and the added moisture was thoroughly mixed with the coal and given 10 min. for absorption. Water was added to this sample in increments of 2 lb. Starting with the dry samples as having zero surface moisture, this gave increments of approximately 5.0 per cent, 10.0 per cent and 14.5 per cent.

The minimum air resistance occurred at an added moisture content of 7.5 per cent. With a constant draft there was a variation in air flow through the fuel bed amounting to a 55 per cent increase in moist coal, as compared to dry coal, and 20 per cent increase for wet coal compared to dry coal.

The conclusions reached from these tests are:

a. Properly tempered coal has less resistance than either very dry or very wet coal,

b. Very wet coal has less resistance to air flow than very dry coal,

c. Moisture added to coal is largely surface moisture and does not penetrate deeply,

d. Particles of coal do not "burst open" due to internal steam formation.

There is probably an aërating effect in the furnace due to formation of steam between the particles of coal which may prevent the binding action of coal tars, thereby keeping the fuel bed more porous.

The decrease in air resistance due to added moisture is advantageous in some furnaces by reason of a noticeable deficiency of oxygen over the fuel bed at the front of many furnaces, particularly those of traveling grates.

Of the chemical effects on combustion due to moisture in coal little is known. The author has conferred with some of our best-known chemists on this subject and learns that the subject has received no analysis, if indeed, a proper analysis of the various reactions be possible.

Due to the physical action of agglomerating fine coal, some time is necessary in order to get a uniform distribution and absorption of moisture for best results. For this reason water added in storage or in coal conveyors has a marked advantage, so far as fuel bed action is concerned, over moisture added in the stoker hopper.

The objection to moist coal in bunkers, coal spouts and conveyors, however, is serious on account of the corrosive action of sulphurous acid on these parts. With the high sulphur coals of the West, this is a serious factor and has caused many to forego some of the advantages of tempering in order to avoid excessive corrosion. Many operators, however, report that cement-lined bunkers and coal spouts, wooden coal spouts and oil-coated bunker sides resist this action.

If coal is to be moistened in the stoker hopper, it is advantageous to use hot or warm water, as this has a greater affinity for coal than has cold water, and the tempering action is much more rapid.

Exhaust steam supplied by means of a pipe in the stoker hopper gives an excellently tempered coal, and in spite of the evident loss due to the steam consumption, this is sometimes a desirable practice. A study should always be made to insure that the advantages are not offset by the cost of the steam used.

The amount of moisture to add to properly temper the coal is a matter of judgment dependent on the quality, size and the condition of the coal. Answers to the author's questionnaire gave between 1½ and 5 per cent—averaging 3 per cent.

The heat required for vaporizing this moisture is low, probably ⅓ per cent with the average coal and with the usual flue-gas conditions, while the advantages due to improved ash, high ratings, less siftings and more responsive fires more than offset this slight loss.

Most of this investigation has been made on traveling grates using Western fuels, but some reports have been received from other fuels and types of stokers. In general, Eastern coals do not require tempering nor respond in furnace action to added moisture as do Western coals. Operating reports from plants using Iowa coal on underfeed stokers report improved results with moistened coal.

*Extract of paper presented at Seventeenth Annual Convention, Association of Iron and Steel Electrical Engineers, Sept. 24, 1923, Buffalo, N. Y.

†Chief engineer, Green Engineering Company, Chicago, Ill.

Contamination of Lubricating Oil*

By W. F. Parrish

Past failures of the individual types of machines and parts are shown by the history of mechanics to have been due largely to a lack of proper lubrication. The one important and economic function of a lubricant is to prevent the wear of all machine bearing and rubbing surfaces. Further, when machines and parts cannot be made so they can be lubricated properly, they cease to be of commercial use and they must be replaced with other machines or parts that will accomplish the same work, but that can operate without the waste due to wear. When better machines are provided, their usefulness is determined to a great extent by the factor of lubrication.

Primarily, lubricating oil is used for the purpose of keeping surfaces apart so that actual contact does not occur. The most economical lubrication is provided when the oil is just thick enough to prevent metal-to-metal contact under a certain pressure, speed and temperature, and is not thick enough to cause a drag on the mechanism. Various factors will cause the surfaces to come together, such as overheating of the oil; dirt or hard substances in the oil that break the film or abrade the metal surfaces and cause heat; and dilution of the oil with some lighter liquid, such as with water or with liquid fuels. The greatest economic value of a lubricant can be secured only when it is allowed to work in an uncontaminated condition. Probably, all mechanical failures can be traced to lack of proper lubrication because the lubricant was in a contaminated condition and could not function properly.

Contamination of the lubricant is caused in many ways. Where lubrication has been effective for months, the air cylinders of air compressors may show seasonal wear due to their having sucked in dry dust and dirt. This material collects on the lubricating film and renders it practically useless for the prevention of wear. The cylinders of steam

*Extract of paper read before the Automotive Service Association, New York City, Oct. 11, 1923.

engines may not have had the tool marks worn off for years, but when boiler trouble occurs and foaming brings over a mass of chemicals, water and solids, these will destroy all traces of the protecting film of lubricant and excessive wear will occur within a very short time. The shaft bearings of steam turbines that are lubricated with oil from a forced-feed system will not give evidence of wear for years; yet, if an excessive amount of water is allowed to enter the lubricating system, emulsion deposits may be formed that will prevent lubrication and the bearings will burn out within a few moments of time. Watches probably are the best examples of successful lubrication with pure uncontaminated oil. Under such conditions they run reliably, but one drop of water or of gasoline and an infinitesimal amount of the finest sand will ruin the works.

The extreme comparison is found in the sand, cement and similar industries, where the machine bearings are exposed to sand, clinkers, steam, water and dirt. Wear is constant and expected under such conditions; it i prepared for adequately and is considered as a part of the business. In these industries, it has been found possible to protect the machine bearings so that the lubricant is not contaminated, and repairs are no more frequent than those made in normal plants.

Under conditions such that dirt is likely to enter the lubricant, it is the custom among lubrication engineers to use the thickest of the oils. The reason is that these thick oils will absorb the particles of dirt to such an extent that they do not become abrasives. The other extreme is to use thin oils with emery or glass abrasives in grinding operations.

These lubrication factors are not confined solely to the practice of the engineering specialists but are, more or less, subjects of common knowledge. The very common saying in all languages: "Don't put sand in the oil" has became an adage. General rules regarding lubrication are also so easy to assume that it is a common practice throughout the world, among persons who oil machinery, to use the thickest oils that can be secured, so that the intervals between oilings will become longer, so that trouble due to wear and hot bearings will be prevented.

The Chief Engineer*

How often I think o' the day I enlisted,
On a bloomin' ol' packet as chief engineer,
An' found her machinery all buckled an' twisted,
From engine room clean to the steam steerin' gear.
The cap'n he said, "Take the damn thing to pieces,
"An' put it together the best way you can,
"We've tightened the j'ints but the trouble increases,
"She needs a mechanic, an' you're jest the man."
'Twas plain to be seen he'd the best o' intention,
An' no one had kidded me that way before,
But the boat was a relic o' Noah's invention,
An' I was quite young in the year '84.

A jungle o' steam pipes that leaked like a basket,
Broke in on my view as I gazed fore an' aft,
An assortment o' valves without packin' or gasket,
That sizzled an' sputtered throughout the ol' craft.
Her engines were jammed an' her pistons were battered,
While she listed to starboard with ballast adrift,
Though my courage was high, my fond hopes became shattered,
For, who'd take the bloody ol' tub as a gift?
But the cap'n he argued an' then he insisted,
An' like an ol' sailor, he cussed an' he swore,
Till quite discomfuddled, I went an' enlisted,
So that's how I started the year '84.

The cap'n he wrung up four bells an' a jingle,
I knew he was callin' for full speed ahead,
So I grabbed the ol' throttle with nerves all a-tingle,
As she made for deep water an' rolled as she sped.
I stuck to my task as she labored an' trembled,
Though expectin' her b'ilers to bust any day,
While I held to her nozzle the gang all assembled,
An' the lubbers they all made a clean get-away.
The coal heavers fled, as the firemen beat it,
The rest o' the crew they pulled out for the shore,
But though left to myself, sure I never retreated,
Which won me a raise in the year '84.

I froze to my post to the last frenzied second,
Well knowin' the hazard would turn my hair gray,
But the darn bus'ness rattled me worse than I reckoned,
For it gave me the bald head I wear to this day.
When the crew had deserted, I felt some disgusted,
An' left thus alone I was more than outdone,
'Twould 'a served 'em jest right if the ol' kettle busted,
An' cooked up the last livin' son-of-a-gun.
Her seams had all parted from keelson to gunnel,
The decks were awash to the pilothouse door,
An' as breakers swept over an' flooded the funnel,
I stuck to the ship in the year '84.

I warped her in under the lea o' the smother
An' came into port in the teeth of a gale,
I saluted the crew as we cheered one another,
An' drank to our fortune with plain ginger ale.
For I was the cap'n, an' also the bo'sn,
Till a-hungered, as sailormen oftentimes do,
An' then I was cook, by majority chosen,
An' the whole bloomin' kit o' that heroic crew.
'Twas a billet I liked if there'd been enough in it,
But hope was inspired by assurance galore,
There was also a prize, if I stayed there to win it,
Is the dope I was fed in the year '84.

The people on deck whom we serve in a welter,
O' grime an' o' sweat, in the dust o' the hold,
Are blind to the woes o' the devils who swelter,
That they may have comforts from heat an' from cold.
Sure there's never a song, an' there's little o' laughter,
An' damn little pleasure that ever gets through,
For life in that dungeon in action an' after,
Is tough on the boss, but it's hell for the crew.
But I've one consolation, I cannot deny it,
One Destiny rules us afloat an' ashore,
An' I've captured the prize, if I did have to buy it,
For I've been on the job since the year '84.

*This poem was written in honor of a faithful old government employee, who, before his entry into the government service, was a marine engineer. He has recently retired from active duty after nearly forty years' continuous service in one position, with only one raise in salary during his entire career. The purport of the poem is intended to camouflage the antiquated methods and equipments in the departments, which he did much to improve. The prize referred to is the Retirement Act, the fund for which was obtained by deducting a small percentage from the employees' salary.

There can be no doubt that interest in pulverized coal as a fuel is rapidly growing in this country (England), and that in the not distant future we shall probably witness a wide extension of its use. In America, since the Lakeside station of the Milwaukee Electric Railway and Light Co. was started at the end of 1920, development has been rapid, so much so that to-day some thirty large plants in the United States are now either running on pulverized coal or are being converted for its use. In Europe developments are also occurring, the most notable perhaps being the large installation now being erected as Vitry in Paris. We in this country have perhaps been a little backward in adopting the system, but at Hammersmith and Durham pulverized fuel plants are to be found which have yielded very satisfactory results. We hear that considerable developments may possibly be expected in this connection at the King's-road station of the St. Pancras Borough Council. Mr. Baynes, the chief engineer, has reported to his Council on the matter and will probably in a short time proceed to America to inspect what is being done there. We notice that there are still some who, having heard that coal dust may be highly explosive, express a fear of the danger entailed in the use of pulverized coal as a fuel. In actual fact there is little or no more danger with modern methods of pulverizing and drying the coal and of handling it on the way to the boilers than there is in the handling of coal gas.—*The Engineer* (London).

News in the Field of Power

Giant Power Survey to Be of Great Benefit

In speaking recently of the Giant Power Survey of Pennsylvania, Morris Llewellyn Cooke, the director, made the following pertinent remarks:

Wherever power is spread it develops civilization. It spreads people out into undeveloped territory; it creates towns, it builds industries, all of which increases the wealth of state and nation.

The Giant Power development project does not intend any interference with the present system of private ownership of utilities in this state. The state does not by means of this project, intend entering the public utilities ownership field.

Governor Pinchot's idea is to show private ownership the way to solve the problem which is now staggering them; that is, how they can cope with the increase in population, the growth of industry and the development of civilization that the not remote future has impending.

The project comprehends reduction in the cost of power by concentrating its production into giant plants located at economic and strategic points, such as at the coal mines, at points where water power is available, etc.

The survey will determine the points where giant power plants can best be located, compile data on the amount of power possible to generate and determine where high-tension electric-current transmission lines can be built to serve the power-consuming centers and to distribute the energy most economically throughout the state.

It will also make a minute study of the utilization of byproducts from the coal, water power and other energy-generating forces. There are approximately 44,000,000 tons of bituminous coal per annum used for power production and not one pound of that has removed from it the valuable byproducts that bituminous coal yields. In ten years we have reached the stage where 78 per cent of coal used for coke making has the byproducts extracted.

Superpower Conference Held by Public Service Commissioners

Representatives of New England and Middle Atlantic States Discuss Superpower Problems, at New York City

CHAIRMEN of Public Service Commissions in the Northeastern states, on invitation of Secretary Hoover, and with the approval of President Coolidge met in New York on Oct. 13 in the Engineering Building, New York City, for a preliminary discussion of steps that may be taken properly by federal and state authorities in the promotion of superpower developments in the New England and Middle Atlantic States to meet the growing, insatiable and general need for power.

The aim of the conference was to discuss steps toward a more effective co-ordinated power production between public authorities and industries in the interest of the public to the end that the widest possible use may be given to the advances made in the development of electric power and to achieve the highest possible national economy in power production and distribution through interconnection of power supplies between existing great utility systems and in common action for the erection of large units of production at advantageous points for the mutual supply of two or more of the present systems and in the national development of great water resources.

Among those who attended the conference were: William A. Prendergast, chairman, New York State Public Service Commission; Commissioner Stone, Massachusetts Department of Public Utilities; William C. Bliss, chairman, Rhode Island Public Utilities Commission; Walter A. Dutton, chairman, Vermont Public Service Commission; Richard T. Higgins, chairman, Connecticut Public Utilities Commission; Harry V. Osborne, chairman, New Jersey Public Service Commission; William D. B. Ainey, chairman, Pennsylvania Public Service Commission; Ezra Whitman, Maryland Public Service Commission; Charles E. Gurney, president, Maine Public Utilities Commission; H. Carl Wold, chief engineer, Maryland Public Service Commission; William T. Gunnison, chairman, New Hampshire Public Service Commission; William S. Murray and E. S. Buckland of the Federal Superpower Commission of 1919; M. H. Aylesworth, manager, National Electric Light Association; O. C. Merrill, Federal Power Commission, and other persons interested in discussion leading to the public receiving of the maximum benefit from the progress made along the lines of superpower and development of electric energy.

On account of the short time before going to press we are unable to give full account of the meeting. However, in the next issue details will be given in full.

President Informed About Federal Safety Conditions

Safety conditions in the Federal service are behind the times, M. G. Lloyd, chief of the Safety Section of the U. S. Bureau of Standards, says in a letter to President Coolidge made public by the Federated American Engineering Societies.

Mr. Lloyd's letter, which follows the recent disaster in the Bureau of Standards, costing four lives, reads:

The disaster which occurred at the Bureau of Standards recently focused our attention once more upon conditions existing in the federal service, which have long been recognized as behind times and not upon a par with modern methods in large private industrial establishments.

The American Society of Safety Engineers took cognizance of this condition two years ago, and I am attaching hereto a resolution passed by its Executive Board at that time. A similar resolution has more recently been passed by the American Engineering Council of the Federated American Engineering Societies, which represent the composite opinion of the engineers of this country.

I write this letter to implore you to include in your next message to Congress a recommendation for legislation which will establish in the federal departments adequate accident-prevention measures such as have been already recommended by the Congressional Joint Committee on Reclassification.

The engineers expect that the matter will be taken up by President Coolidge when he prepares his message to Congress.

Second Power Show Will Have Educational Value

The number, diversity and interest of the exhibits of the Second Exposition of Power and Mechanical Engineering promise to far excel those of the first exposition held in December, 1922. The 1923 exposition is to be held in the Grand Central Palace, New York City, Dec. 3-8. The week of the exposition will be an active period for engineers, for during that time meetings of the American Society of Mechanical Engineers and the American Society of Refrigerating Engineers will be held. These meetings insure an attendance of influential engineers and executives. In addition, the National Association of Stationary Engineers and its affiliated bodies are organizing the interest of their membership, for last year these men, who are so vitally concerned with the operating problems, found the exposition to be of great educational value, and most interesting.

The exhibits will be supplemented

by an extensive program of motion-picture films to be presented in co-operation with manufacturers. Last year the picture program was found to interest the layman who was not informed about technical processes and the engineer whose close application to one field of his work had not enabled him to keep up with progress in the rest of the profession.

About two hundred exhibitors have signed contracts for space. The devices and apparatus to be exhibited cover the field of power and mechanical engineering from the handling of the coal at the power plant until power is turned into work.

U. S. Naval Academy Needs Power-Plant Engineer

The United States Civil Service announces a non-assembled examination to fill a vacancy at the Engineering Experiment Station, U. S. Naval Academy, Annapolis, Md., at an entrance salary of $9.12 per day. The position is that of an associate mechanical engineer (power plant) to act as technical adviser to the officer-in-charge and to take actual control of testing and designing work of power-plant equipment. Receipt of applications will close Nov. 20.

New Publications

Kent's Mechanical Engineer's Handbook. By the late William Kent, Tenth Edition. Rewritten by Robert Thurston Kent, editor in chief, and a staff of 35 specialists. Published by John Wiley & Sons, Inc., New York City, 1923. Limp binding with gold edges; 4¾ x 7 in.; 2,247 pages with numerous tables, curves and diagrams. Price: Genuine leather, $7; Atholeather, $6.

This handbook is not merely the tenth edition of the late William Kent's monumental work. It is truly a new "Kent," rewritten to bring it into line with the most recent engineering practice. With slightly larger type pages and with 700 more of them, the new Kent contains over 50 per cent more material than the ninth edition. A casual inspection reveals at once a great wealth of new material. Useful tables, in particular, are supplied in greater profusion than ever. The book is divided into 27 main sections, each with its own table of contents. The following sections and subsections are entirely new: Fans and blowers; hydraulic turbines, pumps and pumping engines; the steam engine; steam turbines; gas producers, gas engines, gas turbines; oil engines; automotive vehicles; aëronautics; hoisting and conveying; industrial furnaces; forge shop fusion welding and cutting; malleable castings; refrigeration and ice making; reinforced concrete; heating and ventilation; safety engineering. The remaining sections and subsections consist in large part of new material. Space does not permit of any comprehensive survey of the contents. Choosing here and there at random new features of interest to power-plant engineers, the following may be mentioned: Table giving the contents of partly filled horizontal cylindrical tanks; data on carborundum refractories; a tremendous mass of information on piping, fittings, valves, hangers, etc.; shapes, dimensions and properties of firebrick; latest information on the effect of high steam temperatures on metals; the theory and prevention of corrosion; pyrometers; evaporators; a comprehensive study of heat insulation; the new methods of gas computation based on molecular weights; many new diagrams for fans and pumps; data on pulverized fuel; more extensive steam tables; furnace design; feed-water heating and purification; comprehensive sections on steam and oil engines and turbines; new information on lubrication and refrigeration; a greatly enlarged section on electrical engineering. The new Kent is a monument of engineering service that reflects great credit on all who collaborated in its production.

Les Méthodes Modernes d'Organization Industrielle. By L. Benoist, Avec Exemples du Calcul des Temps d'Usinage en Construction Mécanique, by M. Hermann. Published by Gauthier-Villars et Cie., 55 Quai des Grand-Augustins, Paris. Printed in French. Paper; 5¾ x 9 in.; 208 pages. Price, 18 francs.

This treatise on modern methods of organization in industry is addressed particularly to young technicians who are starting out in an industrial career, and is designed to give them an insight into the various phases of industrial management. It takes up a general scheme of organization and defines the various branches of the service with details of the commercial, technical and accounting systems. It gives considerable space and emphasis to the American contribution to this subject, "The Principles of Scientific Management," by F. W. Taylor. The second part of the volume, "Du Calcul des Temps d'Usinage en Construction Méchanique," consists principally of a series of tables by means of which the time that should be consumed by any operation in a factory or plant can be readily determined.

Specifications for Building Equipment Control Apparatus—The Electric Power Club, Cleveland, Ohio, has recently issued a four-page booklet covering specifications for electric power equipment control apparatus used in buildings such as hotels, schools, office buildings, etc. The Controller Manufacturers Association of the Electric Power Club presents these specifications as a summary of the best modern practice as indicated by architects and engineers of wide experience. Adherence to these requirements will permit the simplification of controller manufacture, improved service, economies in installation and other advantages of standardized practice.

Power Test Codes—A.S.M.E. 1923. Test Code for Hydraulic Power Plants and Their Equipment. Developed by a Joint Committee and published by the A.S.M.E., 29 West 39th St., New York City. Paper, 7¾ x 10¾ in.; 22 pages. Price, 65 cents to members and 75 cents to non-members.

Revised Code of Rules for the Construction of Low-Pressure Heating Boilers. Section IV of the A.S.M.E. Revised Boiler Code. Report of Subcommittee of the Code Committee on Heating Boilers. Published by the A.S.M.E., 1923. 29 West 39th St., New York City. Paper, 7¾ x 5¼ in.; 31 pages. Price, 75 cents, which will include the five or so chapters some of which are not yet published, that will make up the entire code.

Society Affairs

The **A.S.M.E.** will deal with the principles underlying the development of hydro-electric power at one of the main sessions of its annual meeting Dec. 3-6. This meeting will be participated in by the A.S.C.E. and the A.I.E.E.

The **National Association of Practical Refrigerating Engineers** have made arrangements for its annual convention meetings to be held in the Scottish Rite Cathedral, and to have headquarters and registration at the Chisca Hotel, Memphis, Tenn., from Dec. 12-15.

The **Army Ordnance Association** will hold its Fifth Annual Meeting at the Aberdeen Proving Grounds, the American Iron and Steel Institute participating, Oct. 26. Demonstrations of Ordnance material by the services which actually use it in battle—the artillery, the infantry, the air service, etc.—are planned.

The Affiliated Technical Societies of Boston are planning a joint dinner on management meetings at the Vendome Hotel, Oct. 25, of the engineering, commercial and banking organizations of Boston. Col. Sanford E. Thompson, regional director of management week for the A.S.M.E., is busy with the committee on the program, which will be of great interest.

The **American Welding Society** will hold its Fall Meeting at the Fort Pitt Hotel, Pittsburgh, Pa., Oct. 24-26. Beside sessions on electric arc welding, gas welding, training of operators, etc., there will be inspection trips to the Westinghouse Electric & Manufacturing Co. plant at East Pittsburgh and to the Carnegie Steel plant at Homestead, Pa.

The **Franklin Union**, 41 Berkeley St., Boston, will hold an educational session on Oct. 27, at 7:45 p.m. Fred R. Low, editor of *Power* and president-elect of the A.S.M.E., will speak on "The Education of the Engineer"; Albert A. Northrop, of Stone & Webster, will give a lecture with slides and motion pictures on "60,000-Horsepower Hydroelectric Plant"; Sanford Riley stoker films will also be shown.

Obituary

Thomas G. O'Dea, treasurer and business manager of the Erie County Electric Co., Erie, Pa., died after a lingering illness on Sunday Sept. 23. Born and educated in Erie, Mr. O'Dea was a pioneer there in the development of the electric industry, having been connected with the company of which he was treasurer from shortly after its establishment thirty-two years ago until about fourteen months before his death.

Personal Mention

Fred W. Fischer, formerly chief engineer of the Old Hickory Powder Plant, is now president of the D. A. & B. Tool Co., Knoxville, Tenn.

General Guy E. Tripp, Chairman of the Board, and **Loyall A. Osborne**, president of the Westinghouse International Company, sailed from San Francisco for Japan on Oct. 10. They will visit Shanghai, Hongkong, Pekin and the Philippines before returning to America.

Herbert Hoover has been elected to honorary membership in the Czechoslovak Engineers and Architects Association, in recognition of "merit in engineering science and practice and good rendered to our people." The honor was conferred at the Annual Conference of the Association held recently at Kosice.

Jesse L. Best, power-plant superintendent for the Missouri Utilities Co., Mexico, Mo., has accepted a position with the Union Electric & Light Co. of St. Louis, as supervising engineer of its Cahokia plant at Venice, Ill. Mr. Best has been with the Utilities Company for the last three years, coming from Hillsboro, Ill.

Business Notes

Manning, Maxwell & Moore, Inc., announces that Walter V. Lawton has been appointed district manager of its Boston district, with offices at 99 Chauncey St.; W. C. Chapman is to be district manager of the Philadelphia district with offices at Fifteenth and Chestnut Sts., and Joseph Wainwright is to be sales manager of the Philadelphia district.

The **Link-Belt Co.**, of 910 South Michigan Ave., Chicago, announces the purchase of the Meese & Gottfried Co. of San Francisco, and a change of firm name to Link-Belt Meese & Gottfried Co., with headquarters at 19th and Harrison Sts., San Francisco, Calif. The officials will be: Charles Piez, chairman of the board; B. A. Gayman, president; Harold H. Clark, vice-president and sales manager; Leslie W. Shirley, treasurer; Richard W. Yerkes, secretary. All the officials will be located in San Francisco with the exceptions of Mr. Piez and Mr. Yerkes.

John R. Nichols, formerly chief engineer Monks & Johnson, Boston, Mass., has opened a consulting engineering office at 161 Devonshire St., Boston, where he will specialize in the design and construction of industrial plants and will handle miscellaneous problems in structural engineering.

Coming Conventions

The American Association for the Advancement of Science. Burton E. Livingston, Smithsonion Institution Bldg., Washington, D. C. Seventy-fifth anniversary meeting at University of Cincinnati, Cincinnati, Ohio, Dec. 27-Jan. 2.

The American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Midwinter convention at Philadelphia, Feb. 4-8.

The American Society of Civil Engineers. John H. Dunlap, 29 West 39th St., New York City. Fall meetings, Richmond, Va., Oct. 17-20.

American Society of Mechanical Engineers, Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 3-6. Regional meeting at Chattanooga, Tenn., Oct. 23-24.

American Society of Refrigerating Engineers, William H. Ross, 35 Warren St., New York City. Nineteenth Annual Convention at New York City, Dec. 3-5.

American Welding Society. M. M. Kelly, 33 West 39th St., New York City. Fall Meeting, Pittsburgh, Pa., Oct. 24-26.

Association of Railway Electrical Engineers. Jos. A. Andreucetti, Room 413, Chicago & Northwestern R.R. Station, Chicago, Ill. Thirteenth Annual Convention at Hotel La Salle, Chicago, Ill., Nov. 6-9.

Electric Power Club. S. N. Clarkson, 900 B. F. Keith Bldg., Cleveland. Fall meeting at French Lick Springs Hotel, French Lick, Ind. Nov. 19-22.

National Association of Practical Refrigerating Engineers; Ed. H. Fox, 5707 W. Lake St., Chicago. Fourteenth Annual Convention at Memphis, Dec. 12-16.

National Exposition of Power and Mechanical Engineering; Charles F. Roth, Room 1102, Grand Central Palace, New York City. Power Show, Dec. 3-8.

New England Association of Commercial Engineers; James F. Morgan, 53 Devonshire St., Boston, Mass. Power Show at Mechanics Bldg., Boston, Mass., Oct. 29-Nov. 3.

Society of Naval Architects and Marine Engineers. Daniel H. Cox, 29 West 39th St., New York City. Annual meeting at New York City, Nov. 8-9.

West Virginia-Kentucky Association of Mine, Mechanical and Electrical Engineers; Herbert Smith, Room 211, Robson-Prichard Bldg., Huntington, W. Va. Third annual convention at Frederick Hotel, Huntington, W. Va., Oct. 19-20.

The **Stone Company**, Commerce Building, Rochester, N. Y., has recently been formed by **Roy L. Stone**, formerly of McClellan & Junkersfeld, Inc. This firm will act as sales agents in New York state outside of the Metropolitan District for the Allen-Sherman Hoff Co., of Philadelphia, the Griscom Russell Co., New York City, M. W. Kellogg Co., Jersey City, the Coffin Valve Co. of Neponset, Mass., and the Chicago Belting Co.

Trade Catalogs

Steam Specialties—Milwaukee Steam Appliance Co., West Allis, Wis. Catalog containing descriptions, illustrations and tables of dimensions of valves, separators, traps, exhaust heads and flue cleaners.

Cable and Cord, Super Service—Rome Wire Co., Rome, N. Y. Catalog containing full descriptions of cord and cable manufactured by this company. Leaflets describing welding cable and super-service junior.

Motors, Heavy Duty—Reliance Electric & Engineering Co., Cleveland, Ohio, Bulletin No. 2014 describes with photos and data tables type T direct-current heavy-duty motors manufactured by the Reliance Company.

Strainers — Elliott Company, Pittsburgh, Pa. Catalog A-2 contains 36 pages of information regarding twin, single, intake types of strainers for all services. Reproductions of drawings as well as photos and tables of dimensions add to the clarity of the presentation.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Oct. 1, 1923	Oct. 8, 1923
Pool 1,	New York	$3.00@3.50	$3.00@3.25
Smokeless,	Columbus	2.85@3.35	2.85@3.25
Clearfield,	Boston	1.85@2.60	1.85@2.50
Somerset,	Boston	2.00@2.75	2.00@2.75
Kanawha,	Columbus	1.75@2.00	1.75@2.00
Hocking,	Columbus	1.75@2.00	1.75@2.00
Pittsburgh No. 8	Cleveland	1.90@2.00	1.90@2.00
Franklin, Ill.	Chicago	2.75@3.00	2.25@3.00
Central, Ill.	Chicago	2.00@2.25	2.00@2.25
Ind. 4th Vein,	Chicago	2.50@2.75	2.50@2.75
West Ky.,	Louisville	1.75@2.00	1.50@2.00
S. E. Ky.,	Louisville	1.75@2.25	1.75@2.25
Big Seam,	Birmingham	1.75@2.15	1.75@2.15

FUEL OIL

New York—Oct. 10, light oil, tank car lots, 28@34 deg. Baumé, 3⅜c. per gal., 36@40 deg. 4c. per gal., f.o.b. Bayonne, N. J.

Chicago — Sept. 28, 24@26 deg. Baumé, $1.82@2.07 per bbl.; 32@36 deg., $2.02@2.07 per bbl., tank cars.

St. Louis—Sept. 25, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.60 per bbl.; 26@28 deg., $1.65; 28@30 deg., $1.75; 32@36 deg., gas oil, 3¼c. per gal.; 36@40 deg., distillate, 3⅜c. per gal.

Pittsburgh—Oct. 2, f.o.b. local refinery, 30@34 deg., fuel oil, 5c. per gal.; 36@40 deg., fuel oil, 5½c.; 34 deg., neutral 7¼c.

Dallas—Oct. 6, f.o.b. local refinery, 26@30 deg., $1.35 per bbl.

Cincinnati—Sept. 25, tank-car lots f.o.b. local refinery, 26@30 deg. Baumé, 5c. per gal.; 30@32 deg., 5¼c.; 38@42 deg., distillate, 6¼c.

Philadelphia—Sept. 27, 26@28 deg., $1.68@1.722 per bbl.; 16@20 deg., $1.64 @1.68; 14@16 deg., $1.57@1.612.

New Plant Construction

PROPOSED WORK

Ark., Little Rock—The Arkansas Power Corp. does not plan to take bids for power dam, etc., on Little Red River, as stated in our issue Sept. 11.

Calif., Los Angeles—L. L. Jones, Archt., Grosse Bldg., is receiving bids for the construction of a 12 story hotel on Bixel and Ingraham Sts. for H. Foote, c/o Architect. Cost will exceed $500,000. Equipment detail not reported. Noted Oct. 2.

Calif., San Francisco—The Constructing Quartermaster, Fort Mason, is receiving bids for furnishing and installing a pump and motor in pumping station at Lobos Creek.

Calif., San Francisco—The Pacific Gas & Electric Co., 445 Sutter St., is having plans prepared for a generator building, also a boiler building on Humboldt St. near Maryland St. Estimated cost $30,000 and $10,000 respectively. Private plans.

Calif., Taft—The city will vote on $150,000 bonds for the installation of electrolier system.

Calif., Woodland—The Union Ice Co., 354 Pine St., plans to build an ice plant, capacity 30 ton per day, on Lincoln and 6th Sts. Estimated cost $40,000.

Conn., Meridan—The Connecticut Light & Power Co. is having plans prepared for the construction of a 3 story substation on Hanover St. Estimated cost $200,000. Private plans.

Fla., Leesburg — The Grass Fiber Co., manufacturer of paper, H. J. Farren, Purch. Agt., is in the market for beating engines, 2,000 lb. capacity, also two water tube boilers, 250 hp.

Fla., West Palm Beach—The Southern Utilities Co. is in the market for a 3,000 kw. generator and a 500 hp. boiler.

Ill., Chicago—Dubin & Eisenberg, Archts., 14 West Washington St., are receiving bids for the construction of a 3 story, 207 x 298 ft. apartment house, including steam heating system, on Woodlawn Ave. near Hyde Park Blvd. for S. E. Silverman and S. Kerman, c/o Architects. Estimated cost $700,000. Noted Sept. 18.

Ill., Chicago—H. Schoenstadt & Sons, 1118 South Michigan Ave., is having plans prepared for the construction of a 3 story theatre, including steam heating system, on Archer and Robey Sts. Estimated cost $500,000. Newhouse & Bernham, 4623 Drexel Blvd., Archts.

Ill., Galesburg — The city, the Illinois Light & Power Co., Illinois Merchants Bank Bldg., Chicago, and the Burlington R.R., 547 West Jackson Blvd., Chicago, are having preliminary plans prepared for the construction of a pipe line from here to Burlington and the installation of a pumping station to supply Galesburg and the Burlington R.R. with water. Cost would be divided as follows: city $500,000, Illinois Light & Power Co., $250,000 and the Burlington R.R., $750,000. Private plans.

Ill., Glenellyn — A local syndicate, c/o Harris & Jilson, Archts., 190 North State St., Chicago, is having preliminary plans prepared for the construction of a 4 story, 150 x 150 ft. hotel, here. Estimated cost $300,000.

Ind., South Bend — Burns & McDonnell Eng. Co., 401 Interstate Bldg., Kansas City, Mo., will receive bids until Oct. 18 (change of date) for the construction of a 73 x 104 ft. pumping station, including concrete foundation and floors; 5 x 150 ft. chimney; two 5,000,000 g.p.d. Corliss pumping engines; two 100 hp. 200 lb. water tube boilers with super heaters, etc., for the city. Noted Sept. 4.

Kan., Arkansas City—The city will soon receive bids for pumping equipment and extensions to distribution system. Estimated cost $53,000. Engineer not announced.

Kan., Tecumseh—The Illinois Light & Power Corp., Peoria, Ill., is having plans prepared for the construction of a 15,000 kw. steam power plant, here. Estimated cost $2,225,000. Private plans.

La., Gibsland—The city is having preliminary plans and surveys made for the construction of a waterworks and distribution system, electric light plant and transmission lines. Estimated cost $50,000. E. T. Archer & Co., 1010 Merchants Bldg., Shreveport, Engrs.

La., New Orleans — The Tuberculosis Hospital is having plans prepared and will receive bids about Jan. 1, 1924, for the construction of a 4 story main building with two 3 story wings, also a 1 story building for experimental purposes on Gentilly Rd. Estimated cost $400,000. S. Stone, Jr., 714 Union St., New Orleans, Archt. Equipment detail not reported.

La., Shreveport—The city voted $1,000,000 for waterworks improvements, including $405,000 for reservoirs and construction; $325,000 for pump house conduit; $106,000 for settling basins; $100,000 for filters; $100,000 for main extensions; $50,000 for outlet sewer, etc. J. N. Chester, Union Bank Bldg., Pittsburgh, Pa., Engr.

La., Shreveport—E. Weil, Archt., Whitney Central Bldg., New Orleans, will receive bids until Oct. 27 for the construction of a 111 x 150 ft. theater building, here, for the Saenger Amusement Co., Tulane and Liberty Sts., New Orleans and Erlich Bros., Shreveport. Estimated cost $750,000. Equipment detail not reported. Noted June 26.

Mich., Detroit—F. Wardell, Dewey and Hamilton Aves., plans to build a 6 story, 150 x 225 ft. apartment house, including steam heating equipment, on Woodward and Kirby Aves. Estimated cost $1,500,000. Engineer or architect not announced.

Minn., St. Paul—The Ford Motor Co., Highland Park (Detroit P. O.) is having plans prepared for the construction of a 1 story, 606 x 1,726 ft. automobile assembly plant and factory, including steam heating equipment, here. A. Kahn, 1000 Marquette Bldg., Detroit, and Stone & Webster Co., 147 Milk St., Boston, Archts.

Minn., St. Paul—The Ryan Hotel Co., 6th and Robert Sts., A. D. Darge, Mgr., plans to build a 12 or 13 story hotel, including steam heating system, on 6th and Jackson Sts. Estimated cost $1,500,000. Engineer or architect not announced.

Mo., Kansas City—J. A. Bruening, 317 Dwight Bldg., is having plans prepared for the construction of a 12 story, 142 x 145 ft. office building on 10th and Wyandotte Sts. Estimated cost $1,500,000. W. W. Huff, 506 Mutual Bldg., Kansas City, Engr. McKecknie & Trask, 719 Lloyd Bldg., Kansas City, Archt. Equipment detail not reported.

N. J., Haledon (Paterson P. O.) — The village will receive bids Nov. 5 for the construction of a pumping station and extension of the water system. H. J. Harder, 129 Market St., Paterson, Engr.

N. J., Jersey City—The Jersey Journal is having plans prepared for the construction of a 12 story, 50 x 100 ft. newspaper and office building on Newkirk St. Estimated cost $1,000,000. F. Sutton, 140 Cedar St., New York, Engr. J. T. Rowland, 100 Sip Ave., Jersey City, Archt. Equipment detail not reported.

N. J., Newark—The Intercoastal Lumber Terminal Co., c/o G. Quayle, Grand Central Terminal, New York, plans to build a lumber plant and substation, here. Estimated cost $2,000,000.

N. Y., Batavia—T. E. Donovan is in the market for refrigeration machinery and equipment for cold storage plant at Elba.

N. Y., Medford Sta.—The Great Eastern Sugar Co., c/o K. Grunwald, plans to build a mill and power plant. Estimated cost $1,500,000.

N. Y., New York—W. H. Gompert, Archt. Bd. Educ., Flatbush Ave., Extension and Concord St., Brooklyn, will receive bids until Oct. 30 for the general construction of James Monroe High School, Boynton Ave. between East 172nd and East 173rd Sts. Former contract rescinded. Noted Oct. 9.

N. Y., New York—Steinway & Sons, 109 West 14th St., are having plans prepared for the construction of a 15 story office and hall on West 57th St. Estimated cost $2,000,000. Warren & Wetmore, 16 East 47th St., Archts. Equipment detail not reported.

N. Y., Palmyra—E. S. Walsh, Comr. of Canals & Waterways, Capitol, Albany, will receive bids until Nov. 8 for Contract 193, Erie Canal, Section 8, completing the construction of a power station, etc., at Lock 29, here.

Ohio, Cleveland—The City Ice & Fuel Co., Cadillac Bldg., is receiving bids for the construction of a 1 story, 79 x 158 ft. ice plant on East 124th St. and Union Ave. Estimated cost $75,000. A. C. Bishop & Co., 830 Guardian Bldg., Cleveland, Archts. Noted Oct. 2.

Ohio, Columbus—The City Ice & Fuel Co., 5th and Naghten Sts., C. M. Rose, Purch. Agt., is in the market for ice making equipment to enlarge plant, also for loading equipment for coal yard.

Ohio, Columbus—The White Cross Hospital Assn., Park St., plans to build a 4 story hospital to contain 150 rooms. Estimated cost $300,000. Engineer or architect not announced.

Ohio, Youngstown — B. F. Keith, 1564 Broadway, New York, J. R. Elliott, 137 Alameda Ave., Local Mgr., is having plans prepared for the construction of a theater building, seating capacity 2,300, on the Public Sq., here. Estimated cost $1,450,000. T. W. Lamb, 644 8th Ave., New York, Archt. Engineer not announced.

Okla., Norman—The city voted $10,000 bonds and will soon receive bids for the construction of a pump house and centrifugal pumps with motors. Peckham & Sutton, 227 West Grand St., Oklahoma City, Engrs.

Pa., Pittsburgh — The Bd. Educ., 1326 Fulton Bldg., G. W. Gerwig, Secy., will receive bids until Oct. 18 for the completion of the South Hills High School, Ruth and Secane Sts., separate bids being received for general heating, heating and ventilating, boilers, temperature regulation, fans, motors, air washers and stokers. Noted July 31.

R. I., Providence—The Providence Lying In Hospital, 96 Parkway St., is having plans prepared for the construction of a 4 story hospital. Estimated cost $800,000. Stevens & Lee, 9 Park St., Boston, Archts. Equipment detail not reported.

Tenn., Martin—The city, D. W. Harper, Mayor, is receiving bids for furnishing and installing oil burners, storage tanks, pumps, etc., for two horizontal tubular type 250 hp. (each) boilers to change light and water plant from coal to oil fuel.

Texas—The Community Power & Light Co., c/o T. A. Cheeves, Marlin, is having plans prepared for the construction of light, power and ice plants at Marlin, Chilton, Rosebud, Mart, Mexia and other towns. Estimated cost $500,000. Private plans.

Tex., Dallas—The Amer. Body Co., 2802 William St., is in the market for 3, 5, 7½ and 10 hp., 25 cycle d.c. motors.

Tex., Fort Worth—The Central Electric Co., 712 North Main St., is in the market for a 75 hp., 3 phase, 220 volt motor.

Tex., Grand Saline—The city is having plans prepared for the construction of a filtration and pumping plant. Estimated cost $80,000. H. N. Roberts, 4227 Irving Pl., Grand Saline, Engr.

Tex., Lubbock—The Texas Technical College, c/o A. G. Carter, Fort Worth, is having plans prepared for the construction of college buildings, here. Estimated cost $800,000. Sanguinet, Staats & Herdick, First Natl. Bank Bldg., Fort Worth, Archts. Equipment detail not reported. Noted Aug. 28.

Va., Graham—The Pocahontas Coal Land Corp., C. L. Shuffleburg, Secy., is in the market for loading and unloading equipment, conveyors, tipple machinery, etc.

W. Va., Wheeling—The Wheeling Steel Corp. is in the market for conveyors, loaders, etc., for development of limestone deposit.

Wis., Algoma—The Algoma Wood Products Co., C. Schmidt, Secy., is in the market for power plant machinery.

Wis., Berlin—The Bd. Educ., P. Talbot, Pres., is in the market for ash conveyor and ash handling machinery for high school building.

Wis., Fond du Lac—Schmidt, Garden & Martin, Archts., 104 South Michigan Ave., Chicago, will receive bids until Oct. 20 for the construction of a 2 story, 55 x 128 ft. boiler and engine house, 70,000 gal. concrete reservoir and equipment, including boilers and piping, for St. Agnes Hospital, c/o M. Marcells, 300 East Division St., here. Noted Sept. 25.

Wis., Milwaukee—The city, Central Bd. of Purchases, City Hall, will receive bids until Oct. 19 for one open feed water heater with independent V notch meter for Riverside pumping station.

Wis., Milwaukee—A. H. Luedecke, 140 8th St. (dairy products), is in the market for refrigeration machinery, about 30 ton, belt or motor driven.

Wis., Neenah—The Fox River Valley Cooperative Co. is in the market for refrigeration machinery and cold storage equipment for proposed cheese warehouse.

Wis., New Holstein—The village, L. Hipke, Clk., will receive bids until Dec. 18 for the construction of a sewerage system, including vitrified and c.i. pipe, manholes, lampholes and sewage pumping station; also for waterworks system, including c.i. pipe, valves, hydrants, castings and an elevated steel tank, 60,000 gal. capacity, on a 100 ft. steel tower. J. Donohue Engr. Co., North 8th St., Sheboygan, Engrs. Bids on pumping equipment will be received later.

B. C., Chemainus—The Victoria Lumber & Mfg. Co., Ltd., E. J. Palmer, Mgr., is in the market for power house equipment.

Ont., Islington — The ratepayers of the Twp. of Etobicoke have authorized the expenditure of $40,000 for extensions to the hydro-electric power lines near here. The work will probably be done by day labor. Estimated cost $40,000. S. Barratt, Clk. N. McNicol, Engr.

Ont., London—The Utilities Comn., Hydro Offices, is having plans prepared for remodeling main substation and installing additional equipment. Estimated cost $30,000. E. V. Buchanan, c/o owner, Engr.

Ont., Simcoe—The Stacey-Wagner Leather Co. is in the market for a Slocum stoker, 30 hp. boiler for low pressure heating, 1 and 2 in. steam piping with elbows, also one 10, one 15 and one 20 hp. motor.

Ont., Toronto — The Canadian Packing Co., 3 Bathurst St., plans to build a meat packing house, including steam heating system. Estimated cost $1,000,000. Engineer or architect not selected. The owner is in the market for cold storage equipment, boilers, pumps, motors, etc.

Ont., Toronto—The city, C. A. Maguire, Chn. Bd. of Control, City Hall, will receive bids until Oct. 23 for one 1,000 g.p.m. portable sewage pump with electric motor. R. C. Harris, Engr.

Ont., Toronto—The Hydro-Electric Comn., Yonge and Shuler Sts., is having plans prepared for the construction of a substation on Danforth Ave. Estimated cost $150,000. Private plans. The owner is in the market for substation equipment, lines and service transformers, oil switches, switches and meters.

Que., Montreal—The Queens Hotel, Ltd., Windsor St., J. A. Raymond, Mgr., plans to build a 10 story, 50 x 60 ft. addition to hotel. Estimated cost $500,000. Engineer or architect not selected.

Que., Outremont—The Sisters of the Holy Name of Jesus, Notre Dame St., E., Montreal, are having plans prepared for the construction of a 5 story mother house on Maplewood Ave., here. Estimated cost $600,000. S. Duchostel, Outremont, Engr. Equipment detail not reported.

Nfld., St. Johns—The Reid Newfoundland Co. is in the market for equipment for power development on Tor's Cove Brook.

CONTRACTS AWARDED

Calif., Los Angeles—The Guaranty Bldg. & Loan Assn., 6364 Hollywood Blvd., awarded the contract for the construction of a 13 story, 75 x 150 ft. bank and office building on Hollywood Blvd. and Ivar Ave. to the W. Simpson Constr. Co., Bank of Italy Bldg., Los Angeles. Estimated cost $900,000. Equipment detail not reported. Noted Oct. 9.

Calif., Los Angeles—The Los Angeles Gas & Electric Co., 645 South Hill St., awarded the contract for the construction of a 12 or 13 story office building on Flower St. near 8th St. to the P. J. Walker Co., Merchants Natl. Bank Bldg., Los Angeles. Estimated cost $1,350,000. Equipment detail not reported. Noted May 1.

Calif., Macdoel—The Butte Valley Irrigation Dist. awarded the contract for the construction of canals, pumping plants, etc., to the C. Thompson & Heuser-Packard Co., Loew State Bldg., Los Angeles. The award is subject to an option given for the sale of $400,000 bonds. Noted Sept. 18.

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BUSINESS NEWS DEPARTMENT
Tenth Ave. at 36th St., New York

Calif., San Francisco—The Pacific Gas & Electric Co., 445 Sutter St., awarded the contract for the foundation of 17 story office building on Market and Beale Sts., to I. M. Sommer, Balboa Bldg., San Francisco. Estimated cost $85,000, total cost $1,500,000. Bakewell & Brown, 251 Kearny St., San Francisco, Archts. Other contracts not awarded. Equipment detail not reported.

Calif., San Francisco—Two Thousand and Six Washington St., Inc., c/o C. A. Meussdorffer, Archt., Humboldt Bank Bldg., awarded the contract for the construction of a 10 story apartment house on Washington St. near Gough St. to R. Trost, 26th and Howard Sts., San Francisco. Estimated cost $625,000. Equipment detail not reported. Noted Sept. 25.

Ia., Dubuque—The city, O. E. Carr, Mgr., awarded the contract for transformers and switchboards for Eagle Point pumping station to Swords Bros. Co., 7th St., Rockford, Ill., $11,192; heating system to Linehan & Molo, 472 Main St., Dubuque. Noted Sept. 25.

Minn., Winona—The State Bd. of Control, Capitol, St. Paul, D. F. Mullen, Secy., awarded the contract for the construction of a 3 story, 200 x 210 ft. school building, including power plant, for the State Teachers' College, here, to the J. A. McDonald Constr. Co., 750 Builders Exch., Minneapolis, $451,742. Noted Oct. 9.

Miss., Jackson—The Lamar Life Insurance Co. awarded the general contract for the construction of a 10 story, 82 x 148 ft. office building to the Sumner Sollitt Co., Natl. Bank of Commerce Bldg., San Antonio, Tex., $415,934; heating, etc., to the Beach Heating & Plumbing Co., 300 South Main St., Fort Worth, Tex., $52,000; elevators to the Otis Elevator Co., 7th St., Fort Worth. Noted Sept. 18.

Mo., Foley—The Sandy Creek Drainage Dist. awarded the contract for the construction of a 1 story, 16 x 24 ft. pumping station, a 145 hp. engine and a 7,500 g.p.m. pump to the Fairbanks-Morse Co., 8th and Spruce Sts., St. Louis. Noted Sept. 11.

N. J., Clen Rock (Ridgewood P .O.)—The village awarded the contract for extending the sewerage system to the Paterson Contg. Co., 111 Water St.; construction of pump house to E. B. Edgar, Scotia, N. Y. Noted July 10.

N. J., Kearny—The Public Service Corp., Terminal Bldg., Newark, awarded the contract for the construction of a power station, here, to the Public Service Production Corp., Terminal Bldg., Newark. Estimated cost $20,000,000. Noted Apr. 24.

N. J., Wallington (Rutherford P. O.)—The Passaic Valley Sewerage Comrs., J. H. Quigg, Secy., 900 Chamber of Commerce Bldg., Newark, awarded the contract for furnishing and erecting pumping machinery and equipment for pumping station, here, to the Shevlin Engr. Co., Inc., 259 West 34th St., New York, $44,239. Noted Sept. 18.

N. Y., New York—The Ards Bldg., Corp., c/o G. A. Bagge & Sons, Engrs. and Archts., 299 Madison Ave., will build an apartment house at 55 West 11th St. by day labor. Estimated cost $1,500,000. Equipment detail not reported.

N. Y., New York—One Hundred Forty One East 72nd St., Inc., c/o Rouse & Goldstone, Engr. and Archt., 512 5th Ave., will build a 15 story apartment house on 72nd St. and Lexington Ave. by day labor. Estimated cost $500,000. Equipment detail not reported.

N. Y., New York—The W. H. Peckham Syndicate, c/o G. F. Pelham, Engr. and Archt., 200 West 72nd St., will build an 85 x 100 ft. apartment house on Lexington Ave. and 36th St. by day labor. Estimated cost $500,000. Equipment detail not reported.

Ohio, Alliance—The W. W. Campbell Co. awarded the contract for the construction of a 1 and 2 story factory, office and boiler house to the Boldt Constr. Co., 1969 East 70th St., Cleveland. Estimated cost $75,000.

Tenn., Lawrenceburg—The city awarded the contract for the construction of a hydroelectric dam over Shoal Creek to the Gould Constr. Co., Independent Life Bldg., Nashville. Estimated cost $80,000. Noted Oct. 2.

Tenn., Nashville—The Peabody Teachers College awarded the contract for the construction of a 3 story demonstration building on the campus to the Hegeman-Harris Constr. Co., 185 Madison Ave., New York. Equipment detail not reported. Noted Jan. 16.

Tenn., Nashville—Vanderbilt University, J. H. Kirkland, Chancellor, awarded the contract for the construction of medical buildings, including hospital, nurses' home and power house, to the Hegeman-Harris Co., 185 Madison Ave., New York. Estimated cost $2,000,000. Equipment detail not reported. Noted Oct. 9.

Tex., Fort Worth — The Methodist Hospital, c/o W. H. Matthews, 3920 Ave. G, awarded the contract for excavation for hospital building on Cannon and 6th Sts. to Southwell & Addott, First Natl. Bank Bldg., Fort Worth. Estimated cost $30,000, total cost $1,000,000. The general contract will be awarded about Jan. 1. W. G. Clarkson, First Natl. Bank Bldg., Fort Worth, Archt. Equipment detail not reported. Noted July 10.

Wis., Milwaukee—The Gridley Dairy Co., 1329 North Ave., awarded the contract for the construction of a 1 story, 42 x 105 ft. addition to dairy to the Dahlman Constr. Co., 456 Broadway, Milwaukee. Cost between $35,000 and $45,000. The owner is in the market for an engine driven ice machine.

Wis., Milwaukee—The Thorner Heat Treating Co., 126 Ferry St., awarded the contract for the construction of a 1 story, 48 x 100 ft. heat treating plant on National Ave. to Kohl & Keating 428 Grand Ave., Milwaukee. Estimated cost $40,000. The owner is in the market for special furnaces.

B. C., Point Grey—The city awarded the contract for a new lighting system to Farr, Robinson & Bird, 546 Howe St., Vancouver. Estimated cost $58,000.

Ont., Hamilton—The Council awarded the contract for equipment for substation on Beach Rd. to the Westinghouse Co., Ltd., Hamilton. Estimated cost $90,000. The owner also plans to expend $14,000 for putting power lines underground. A. McFaul, City Hall, Engr. Noted Sept. 11.